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USSR Space Life Sciences Digest

Issue 11

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To our readers: We are working in a large number of highly technical, specialized areas for which adequate Russian-English glossaries have yet to be compiled. We ask your help in improving the accuracy and specificity of our English terminology. Please fill out the form below whenever you encounter an incomprehensible, incongruous, awkward or otherwise inappropriate term. While we solicit all suggestions for improved renderings, the statement that a term is inappropriate provides us with useful information, even when no better alternative can be suggested. A copy of this form will appear in all future issues of the Digest. Thank you for your help.

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FROM THE EDITORS

This is the eleventh issue of the USSR Space Life Sciences Digest. This is a special "double" issue of the Digest covering papers in two issues [20(6) and 21(1)] of Space Biology and Medicine, as well as articles in other journals and monographs. We repeat our offer, made in Digest Issue 9, to entertain requests from readers to publish particular tables and figures the titles of which have been cited in previous issues of the Digest.

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ADAPTATION

(See also: Enzymology: P495; Group Dynamics: P466; Hematology: P474;
Operational Medicine: P470)

PAPERS:

P480(11/87)* Berezovskiy VA, Serebrovskaya TV, Ivashkevich AA.

Individual differences in human adaptation to high altitudes.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 34-37; 1987.

[18 references; 5 in English]

Cardiovascular and Respiratory Systems, Gas Exchange, Ventilation, Hypoxia
Tolerance; Hematology, Blood Biochemistry; Human Performance, Physical
Work Capacity

Humans, Males, Individual Differences
Adaptation, High Altitude, Hypoxia

Abstract: Subjects in this study were two groups of healthy young men who had always lived at sea level. The first group contained 24 men (mean age 19.6) who spent a year working under conditions where $pO_2=120$ mm Hg (altitude 1680 m); group 2 contained 17 men (average age 20.5) who spent the same period in an environment where $pO_2=90$ mm Hg (altitude 3650 m). Studies were made in the morning on an empty stomach. V_E and gas exchange parameters were measured at rest. Sensitivity to hypoxia was determined by having subjects rebreath air into a spirometer with the test being terminated when verbal contact was lost. The PWC₁₇₀ test was used to determine physical work capacity and V_{O2max} . Arterialized blood was taken from a finger at rest and in the first 15 seconds of graded physical activity. Blood pH was also determined, as were concentrations of lactic acid, and pyruvate. Although the altitude at which testing occurred is not specified, apparently each group was tested at the altitude to which adaptation had occurred.

Results showed significant differences between physiological and biochemical parameters of the 2 groups. Minute volume was higher in group 2 than in group 1, primarily because of differences in respiratory volume. Group 2 showed a higher proportion of alveolar ventilation in the overall pulmonary ventilation volume and was more sensitive to hypoxia. Systolic blood pressure was somewhat higher in group 2 than in group 1. Oxygen intake and carbon dioxide output were lower in group 2 than group 1. Concentration of lactic acid was 47% higher in group 2 than in group 1, but there were no differences in pyruvate concentration. The higher ratio of lactate to pyruvate in group 2 testifies to intensified anaerobic processes at $pO_2=90$ mm Hg. In addition, group 2 displayed a greater deficit in buffer bases and decreased concentration of bicarbonates in blood, suggesting the development of metabolic acidosis. However, no changes in blood pH were

P480

seen. Group 2 showed a decrease in physical work capacity and V_{O2max} compared to group 1, and a greater increase in acidosis in response to exercise. When individual differences were examined, it was found that subjects who displayed the highest rate of anaerobic metabolism under hypoxia at rest differed from those with lower lactate/pyruvate ratios (LA/PA) in a number of functional parameters. To corroborate this statistically, subjects were divided into 3 groups on the basis of the value of this ratio. Analysis showed that individuals with the highest glycolysis rate were less sensitive to hypoxia, and had depressed physical work capacity. In response to exercise these subjects tended to show greater increases in LA/PA and greater acidosis in the blood. These results are interpreted as showing that a year's stay in an environment where $P_{iO_2}=90$ mm Hg leads to marked adaptive changes in regulation of respiration and gas exchange, as well as changes in biochemical parameters of the blood. Sensitivity of the respiratory center to hypoxia increases. Since adaptive changes do not fully compensate for chronic hypoxia, signs of secondary tissue hypoxia can be found, and work capacity is diminished. It has also been demonstrated that healthy people of the same sex and age differ in adaptation to hypoxic hypoxia. Some develop powerful compensatory reactions, causing ventilation sensitivity to hypoxia, and increasing pulmonary and circulatory ventilation. As a result, concentration of lactic acid in the blood increases insignificantly and physical work capacity remains high. However, these same individuals show reduced tolerance for limit values of pO_2 and the terminal value of pO_2 in alveolar air during rebreathing is raised. On the other hand, those who show high levels of anaerobic glycolysis, with high MA/PA ratios, decreased ventilatory sensitivity to hypoxia, and depressed physical work capacity, are more tolerant of very low values of pO_2 in the air they breathe.

Table: Biochemical parameters of blood at rest and during graded physical exercise after 1 year's exposure to hypoxia

Figure: Physiological and biochemical parameters of subjects with depressed and increased levels of anaerobic glycolysis under conditions of chronic hypoxia

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P497(11/87) Serebrovskaya TV, Dubrovskaya TG.

Responses of the respiratory system to hypoxic and hypercapnic stimuli in humans adapted to high altitudes.

Fiziologiya Cheloveka.

13(1): 58-63; 1987.

[33 references; 15 in English]

Authors' affiliation: A.A. Bogomolets Institute of Physiology, Ukrainian Academy of Sciences, Kiev.

Cardiovascular and Respiratory Systems, Gas Exchange, Ventilation, Hypoxia and Hypercapnia Tolerance; Hematology, Blood Biochemistry; Human Performance, Physical Work Capacity
Humans, Males
Adaptation, High Altitude, Hypoxia

Abstract: This paper concerns the same study and data as the preceding abstract (P480). However, data from a sea-level control group is included, emphasis is on group rather than individual differences and greater focus is placed on the hypoxia and hypercapnia data. Group 1 (n=17) is the sea-level control; group 2 (n=24) the group acclimated to moderately high altitude (1680 m) for 1 year; and group 3 to high altitude (3650 m) for the same period. Most parameters measured and measurement procedures are the same as in P480. A procedure not emphasized in the previous article involves examining response to hypercapnia. This was measured by rebreathing with an initial gas mixture with 40% O₂ in nitrogen at sea level and 70% O₂ at high altitudes. P_iO₂ at the end of the test for hypercapnia was about 20% at sea level and 50% at high altitude. The test continued for 3-4 minutes until subjects experienced symptoms of distress.

Group differences in parameters of gas exchange and ventilation for the 3 groups are very regular, with group 2 consistently being intermediate in parameter value between group 1 and group 3. Increasing altitude was associated with decreased partial CO₂ and O₂ pressure, increased respiratory minute volume, decreased oxygen and CO₂ consumption, and increase in the ratio of alveolar ventilation to total volume of pulmonary ventilation. Reaction to hypoxic stimuli was assessed on the basis of the following parameters: initial values of partial oxygen pressure and minute volume, and slope of the curve of $V_E/P_{A}O_2$ in phase 1 of the reaction; values of V_E and $P_{A}O_2$ at the curve's inflection point, and slope of the curve in the second phase of reaction; value of $P_{A}O_2$ and maximum ventilation at the point of loss of consciousness; analogous measures were used to evaluate response to hypercapnia. Rate of hypercapnia development in the first phase of the reaction was no different for groups 1 and 2, but was faster for group 3. Differences among groups were greater in the second phase of reaction. The higher the altitude a subject was acclimated to, the lower the pO₂ at which loss of consciousness occurred.

Table: Parameters of ventilation and gas exchange in subjects living at sea level, moderately high, and very high elevations

Figure 1: Ventilatory response to hypoxic and hypercapnic stimuli after adaptation to high altitudes

Figure 2: Level of physical work capacity and biochemical blood parameters of individuals with high and low sensitivity to hypoxia

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MONOGRAPH:

M105(11/87) Gazenko OG, Meyerson FZ, et al., editors.
Fiziologiya adaptatsionnykh protsessov. Rukovodstvo po fiziologii.
[The physiology of adaptive processes. A physiology handbook.]
Moscow: Nauka; 1986.
[635 pages]

Affiliation: Book: Scientific Committee on Multidisciplinary Problems in Human and Animal Physiology, Physiology Division, USSR Academy of Sciences; Chief Editors: Institute of Biomedical Problems, USSR Ministry of Health

KEY WORDS: Adaptation, Stress, Hypoxia, Physical Exercise, Cold, Heat, Injury; Psychology, Memory, Conditioned Responses; Operational Medicine; Cardiovascular and Respiratory Systems; Musculoskeletal System; Metabolism; Gastrointestinal System

Annotation: This book summarizes results of research on the molecular, cellular, and systemic mechanisms underlying adaptation to the environment, i.e., on the physiology of adaptive processes. It examines the general principles of individual/phenotypic adaptation to the environment. Individual chapters cite the results of studies of the adaptive process to such environmental factors as physical exercise, hypoxia, high temperature, cold, nutrition, chemical environmental factors, etc. These discussions focus on fundamental mechanisms of adaptation to the particular factor and on the possibility of correcting disorders of environmental adaptation.

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AVIATION PHYSIOLOGY

PAPER:

P496 (11/87)* Rudnyy NM, Bodrov VA.

Current problems in aviation physiology.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 4-11; 1987.

[11 references; none in English]

Aviation Physiology, Review Article

Personnel Selection; Human Performance, Pilots

Adaptation, Hypoxia, Acceleration; Psychology, Work-rest Schedules,

Fatigue, Biofeedback, Pharmacological Countermeasures; Neurophysiology,

Vestibular System; Perception, Light

Abstract: This review article identifies a number of lines of research as important in present-day Soviet aviation physiology. Aviation physiology research involves the study of the compensatory and adaptive capacities of a pilot or flight crewmember, identification of the details of his adaptation to flight factors, and development of means and methods to protect him from the adverse effects of these factors. When high-altitude hypoxia is counteracted by breathing high pressure oxygen, the circulatory hypoxia which may develop can be minimized with special compensatory clothing. However, this clothing is uncomfortable and interferes with working. One task of aviation physiology is to develop new ways of protecting against high-altitude factors while maintaining optimal working conditions for the crew. Another line of research related to hypoxia is the study of processes that accelerate adaptation to moderately high altitudes by conditioning transport, regulatory and energy-related mechanisms, or through use of drugs. The author also discusses the line of research involving study of the cumulative effects of high and prolonged acceleration, individual differences in acceleration tolerance, and mechanisms which compensate for the adverse effects of acceleration. More reliable methods of predicting an individual's resistance to motion sickness must also be developed to facilitate differential selection of flight crews for various types of aviation duties on the basis of vestibular functioning. More research must be done on identifying and protecting against the effects of high noise levels on the mechanoreceptors of various parts of the body, especially in the lungs and abdominal cavity. With regard to vision, important research entails study of contrast sensitivity to light signals having various temporal and spatial parameters, mechanisms for reception of blindingly bright lights and the search for light shields, and the perceptual characteristics of collimator displays. There is need to look at results of simultaneous exposure to a number of adverse factors; in particular, whether an adaptive-protective response to one factor enhances or interferes with the adaptive responses to the others. With regard to pilot selection, Soviet aviation physiology needs to further improve methods for identifying hidden pathology or functional disorders which are inimical to flight safety, as well as to develop methods of evaluating the state of relatively stable and occupationally significant functions. Study of the relation of lateralization of functions to flight performance is judged particularly important.

With regard to psychological functions, the author emphasizes the need to understand the mechanism through which memory traces are consolidated, as well as to further study the role of feedback in the development of flight skills. Another important research area involves work directed at finding the optimal level of workload for flight crews, where loads which are too light may not be conducive to optimum skill acquisition, and those which are too heavy may lead to exhaustion. Schedules of work and rest are also of great concern; of particular interest is investigation of the dynamics of recovery after a flight shift. It has been established that the course of recovery is quite different after a day flight than after a night flight. One of the most important tasks of aviation physiology is to develop ways and means to control functional state. Work here takes two basic directions. The first of these entails applying knowledge physiology and psychology to the design of pilot working conditions. The second direction involves operating directly on the pilot himself, including individualized flight schedules, psychosomatic regulation (biofeedback), and drugs. Some of these, e.g., the effects of stimulation of biologically active points on the skin, or of the neuromuscular system, require intensive further study. So-called flight fatigue is another research target, which requires study of parameters indicative of status in 3 areas: professional, functional, and reserve capacities of a pilot. In general, aviation physiology requires a better understanding of the interrelationship between physiological functions and psychological processes.

BIOLOGICAL RHYTHMS: See Biospherics: BR11; Microbiology: P106;
Operational Medicine: CR5

BIOSPHERICS

(See also: Nutrition: P475; Operational Medicine: CR5)

BOOK REVIEW:

BR11(11/87) Review of Sidyakin VG, Temur'yants NA, Makeyev VB, Vladimirskiy BM. Kosmicheskaya Ekologiya [**Space Ecology**]. Kiev: Nauk. dumka: 1985. See Digest Issue #5: M58. Reviewed by Kholodov YuA, Lebedeva NN. In: Uspekhi Fiziologicheskikh Nauk. 18(1): 120-122; 1987.

KEY WORDS: Biospherics, Solar Activity; Radiobiology, Geomagnetic Fields; Cardiovascular and Respiratory Systems; Neurophysiology; Hematology; Biological Rhythms; Operational Medicine, Epidemiology

The possibility that natural electromagnetic fields may affect biological subjects is an issue which has not yet been resolved; an essential prerequisite of its resolution is a multidisciplinary approach. This requirement is reflected in the authorship of this book, which includes an astrophysicist, a physician, and 2 biologists who have worked together for almost 20 years researching complex issues involved in mathematical electromagnetic biology. The Semferopol' school of electromagnetic biologists grew out of the many years of collaborative research on the part of specialists in a number of fields. The solution of ecological problems is an important focus of the work of this school.

This book, which is a piece of original research unique in the Soviet and international literature, presents an analysis of a broad range of information cited in the literature, as well as of experimental data obtained in recent years, all of which suggest that the concept of environment and, consequently I.M. Sechenov's concept of organism, must include space factors, particularly solar factors.

The work under review examines a variety of physical phenomena demonstrating the link between solar activity and the biosphere, as well as the theoretically and experimentally supported concept of the critical role of extremely low frequency electromagnetic fields in the realization of that link.

This book consists of a foreword, introduction, five chapters, a conclusion, two appendices and bibliography, including 418 Soviet and 121 foreign publications. Although the bibliography cannot be considered exhaustive, the ratio of Soviet to foreign references reflects the greater emphasis placed on the study of space ecology in the USSR. The authors rightly note the seminal role of the works of V.I. Vernadskiy, the founder of the science of biospherics and of A. L. Chizhevskiy, the founder of heliobiology.

The introduction provides a brief history of the problems discussed in the book, and does not omit the skeptical views of scientists, past and

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present. The objective scientific style of the introduction is retained throughout the book.

The first chapter, "Solar activity and the environment," contains important information about solar activity. The reader is introduced to the major types of solar radiation -- electromagnetic (wave) and corpuscular, known as the solar wind; the sun's magnetic field, the active zones, and the effects of all these factors on the Earth's magnetic field, and on changes in weather and climate. A summary table listing the most ecologically important physical parameters affected by solar activity is given at the end of the chapter. This sort of systematic presentation is particularly useful for specialists in biology and medicine. It is interesting to compare the space factors with their anthropogenic analogues, especially in the area of electromagnetic pollution.

The second chapter, "Empirical data on the effects of space factors on biospheric processes," reviews the literature relevant to the link between solar and magnetic activity and biological parameters. The review covers a broad spectrum of biospheric phenomena influenced by space factors: the state of certain physical-chemical systems, the vital activity of microorganisms and plants, and changes in the functioning of various human systems and in susceptibility to disease. The nervous and circulatory systems are the most sensitive to solar activity.

In the majority of cases, naturally occurring disturbances of various environmental parameters have a complex etiology, with several components of solar activity varying simultaneously against the background of the usual changes in meteorological parameters (air pressure, humidity, wind speed and direction, and temperature).

The link between geophysical phenomena and solar activity is the subject of the third chapter, "The ecological role of environmental parameters affected by solar activity." This chapter considers such factors as atmospheric ultrasound, fluctuations in the radioactivity of the atmosphere, ultraviolet radiation, and electric and electromagnetic fields. It is noted that weak ultrasound is an active biological factor.

Although atmospheric radioactivity increases by a factor of 5 during electromagnetic storms, this is not a significant factor in the effects of solar activity on the biosphere. The effect of ultraviolet radiation on the occurrence of melanoma in humans is well known, as is the positive correlation between ultraviolet radiation and increase in the concentration of mitogenetic substances in the environment. The ecological significance of this factor requires further research.

Variation in the electrical field (Earth's potential gradient) as a function of solar activity has been insufficiently studied, although it is of well-known ecological significance. Of the entire spectrum of the electromagnetic field observed on the Earth's surface, ecologically significant effects are most likely to be found in the extremely low frequency range, which contains the low frequency ionospheric "transparency window," where the field intensity is greatest and the differential between calm conditions and disturbances is quite large.

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The fourth chapter, "Experimental investigations of the biological effects of weak extremely low frequency electromagnetic fields " is devoted mainly to the authors' own work. The authors have conducted extensive multi-factor research concerning the biological effects of electromagnetic fields of various frequencies, but especially of 8 Hz, on rats, rabbits, and dogs. Field intensity in these experiments exceeded that of natural disturbances by a factor of 10-100, and duration of a single exposure was 3 hours. They studied the effects of electromagnetic fields on the cardiovascular, nervous, and blood systems, the systems most sensitive to fluctuations in solar activity.

It was established that heart rate decreases by 10%, amplitude of P and T waves decrease, and the R-R interval increases, and also that the magnitude of changes increases with exposure duration. Changes in the myocardium showed up 2-3 days after the beginning of exposure.

Effects on blood in rabbits involved changes in the ratios of various types of leukocytes: increasing lymphopenia accompanied by marked neutrophilia. In mature dogs such changes were virtually absent, although they occurred in puppies.

Exposure to electromagnetic fields led to changes in the bioelectric activity of the brain, disruptions of the formation and manifestation of conditioned reflexes and delayed reactions. The authors believe that the basis for the effects of electromagnetic fields lies in their effects on regulatory systems.

It is demonstrated that biological effects of electromagnetic fields in extremely low frequency ranges are a function of exact frequency. Thus, different field strength sensitivity thresholds were noted for different frequencies (0.02 Hz and 8 Hz); and the responses of blood to these frequencies were opposite.

The authors found that isolation of mammals from environmental electromagnetic fields had adverse consequences. The authors do not discuss the mechanism underlying the biological effects of electromagnetic fields, nor do they touch upon the problems of biomagnetism, but limit themselves to stating the thesis that natural electromagnetic fields play an important ecological role.

Chapter five, "Solar activity and biological rhythms," examines synchronization of biological rhythms of animals and communities of animals resulting from cyclic changes in environmental factors.

Circadian rhythms are synchronized by diurnal changes in environmental factors, particularly light. For a wide range of macrorhythms, connections have been found between rhythms in solar and geomagnetic activity and certain biorhythms, including rhythms in the course of certain diseases and the occurrence of epidemics. There is a surprising similarity between the periods (frequencies) of microrhythms and certain well-known physical periodic phenomena (human EKG -- Pc. 1?? geomagnetic pulsation, human EEG alpha waves and the fundamental frequency of ionospheric wave guides, etc.). A synchronizing signal having a period of approximately a week was

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found to be widespread in the biosphere. The key factor here was shown to be the sector structure of the interplanetary magnetic field, which has characteristic quasiperiods of 6-9 and 12-15 days.

The conclusion of this book gives a descriptive model of the effects of variations in solar activity on the interplanetary magnetic field. These data will help readers compare the temporal characteristics of biological processes with those of geophysical phenomena.

The book is well written, and contains 23 tables and 59 figures. It is somewhat irritating that the title of table 22 reads "biomagnetic" instead of "geomagnetic." Some figures do not show the variance of experimental data (53-57) or do not include a calibrated scale. However, on the whole, the illustrative material is good.

This work is a significant contribution to the development of electromagnetobiology. Unfortunately, only 1000 copies of this timely work have been printed.

BODY FLUIDS

(See also: Cardiovascular and Respiratory Systems P451; Developmental Biology: P482; Endocrinology: P477; Nutrition: P475)

PAPERS:

P450(11/87)* Smirnova TM, Kozyrevskaya GI, Lobachik VI, Zhidkov VV, Abrosimov SV.

Individual differences in fluid-electrolyte metabolism under exposure to a 120-day period of hypokinesia with head-down tilt and the efficacy of prophylactic measures.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 21-24; 1986.

[9 references; 1 in English]

Body Fluids, Metabolism, Fluid-Electrolyte Metabolism
Humans, Males, Individual Differences

Hypokinesia, Head-down Tilt; Countermeasures, Drugs; Musculoskeletal System, Physical Exercise; Nutrition, Vitamin D

Abstract: Subjects in this experiment were 15 healthy males, aged 24-40, who were subjected to 120 days of bed rest with head-down tilt of -5° . Four of the subjects (group 1) were given pharmacological countermeasures, including drugs to prevent disturbance of mineral metabolism (xydiphon, glucamac), to correct lipid metabolism and pancreatic function (solism, F-99), and to stimulate hemopoiesis (folicobalamin). Four subjects (group 2) followed an exercise regimen directed at preventing disruption of the function of the skeletal muscles and involving contraction of these muscles. Four subjects (group 3) received both treatments, and the remaining three (group 4) received no prophylactic measures. Subjects in groups 1 and 3 also received ultraviolet ray treatment to compensate for a deficit in vitamin D. Before hypokinesia, subjects were studied during a 32-day baseline period to determine initial metabolic and body fluid parameters. Diet was the same during the baseline and treatment periods. Urine was collected daily; while feces were collected in total for each 4-day period. Mineral composition of feces and food was determined using standard methods and mineral content of perspiration was also measured. Total volume of water in the body, volume of extracellular fluid, volume of circulating plasma, volume of intracellular fluid, and volume of interstitial fluid were estimated 3 days before treatment, and on day 60 and 120 of hypokinesia.

Sodium balance was negative in 2 subjects in group 4 (control) and all subjects in groups 2 (exercise) and 3 (exercise + drugs). In all but one of these subjects volume of intracellular fluid was depressed by the end of the experimental period. One subject in group 4 and all subjects in group 1 (drugs) had a positive Na balance. In these subjects, intracellular fluid was elevated compared to baseline. In all subjects of all groups, extracellular fluid was depressed compared to baseline. Subjects in group 3 showed almost no change in intracellular fluid from baseline, while this quantity was elevated in group 1 and depressed in group 2. Individual variability was high in all groups. The authors conclude that the positive Na^+ balance associated with pharmacological agents during exposure to hypokinesia with head-down tilt occurs by virtue of altered fluid-

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electrolyte metabolism between interstices and tissues. The effects of physical exercise, on the other hand, are associated with maintenance of a higher volume of blood. The state of group 3 subjects is concluded to be most desirable, since changes in this group left the intracellular space virtually unaffected, while changes in plasma volume and losses of water and salt are relatively easy to compensate for through intake. The authors argue that high intragroup variability indicates that individual differences in baseline fluid-electrolyte metabolism may explain differences in reactions to long periods of hypokinesia with head-down tilt. Innate individual differences should be considered when countermeasures are prescribed.

Table 1: Relationship between Na balance and changes in total body fluid volume, and extra- and intracellular fluid

| Group | Na ⁺ , mequiv/120 days | TBFV, l | ECFV, l | ICFV, l |
|----------------|-----------------------------------|----------------------------|-----------------------------|----------------------------|
| I (Na down) | -6.0 ± 1.9 | -3.5 ± 0.5 (-6.7 ± 1.0) | -2.5 ± 0.4 (-13.0 ± 1.5) | -1.0 ± 0.4 (-3.1 ± 1.7) |
| II (Na up) | 5.9 ± 1.7 | -1.3 ± 0.2 (-2.8 ± 0.6) | -2.1 ± 0.6 (-14.6 ± 1.9) | 1.4 ± 0.4 (5.2 ± 1.1) |
| | P < 0.001 | P < 0.02 | -- | P < 0.01 |

Numbers in parentheses refer to percentage change; TBFV = total body fluid volume; ECFV = extracellular fluid volume; ICFV = intracellular fluid volume)

Table 2: Changes in Na⁺ balance and fluid volumes in response to different prophylactic measures

| Group | Na ⁺ mequiv/120 days | TBFV, % | ICFV, % | ECFV, % | CPV, % | IFV, % |
|-------|------------------------------------|----------------------------|-------------|-----------|----------|-----------|
| 1 | 4.9±1.8 | -2.4±0.6 | 5.8±1.1 | -15.0±2.4 | -7.8±3.1 | -16.7±3.4 |
| 2 | -7.0±1.3 | -8.5±1.3 | -5.3±2.7 | -13.8±3.2 | 3.0±9.6 | -17.0±5.4 |
| 3 | -5.7±2.7 | -5.0±1.7 | -0.6±3.0 | -12.0±2.5 | -3.4±3.5 | -14.7±3.0 |
| 4 | -3.7±8.4 | -6.3±1.2 | -1.5±2.7 | -13.2±0.7 | -4.0±2.7 | -14.3±0.9 |
| | P(2-1)<0.01 P(1-3)<0.02 | P(4-1)<0.05 P(2-1)<0.01 | P(4-1)<0.05 | -- | -- | -- |

CPV = circulating plasma volume; IFV = interstitial fluid volume

BOTANY

(See also: Microbiology: P106)

PAPER:

P504(11/87) Anikeyeva ID, Balayeva AV, Vaulina EN, Vikhrov AI, Kostina LN, Maksimova YeN, Nevzgodina LV, Potapov YuV.

[A study of] Genetic effects Induced by accelerated carbon ions (320 MeV/nucleon).

Radiobiologiya.

XXVII(1): 103-107; 1987.

[10 references; 5 in English]

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Genetics, Plant Genetics, Mutations, Chromosome Damage

Botany, Arabidopsis thaliana (L) cress, Crepis capillaris (L) Wallr hawk's beard, Lactuca sativa L lettuce

Radiobiology, HZE, Accelerated Carbon Ions

Abstract: This experiment was intended to study the effects of streams of accelerated carbon ions with energy close to the maximum of that of galactic radiation on the genetic structure of plants. Air-dried seeds of Arabidopsis thaliana (L) cress, Crepis capillaris (L) Wallr hawk's beard, and Lactuca sativa L lettuce were housed in a biocollector of the type used in space. The seeds were irradiated with accelerated carbon ions with energy of 320 MeV/nucleon. A nuclear photoemulsion was used as a detector. This detector recorded tracks of the carbon ions and particles of concomitant radiation resulting from interaction of carbon ions with the walls of the accelerator chambers, collimators, and air. Concomitant radiation included grey particles (protons with energy of 30-150 MeV) and black particles (short-lived? protons and multicharged ions with energy $E < 30$ MeV). The seeds were moistened one week after irradiation. This time interval corresponds approximately to the time between the landing of a spacecraft and the moistening of space-flown seeds for growth. The plants were grown under constant illumination at 22-25°C until fruiting. Effects of radiation on the root meristem were estimated by counting aberrant cells, including cells with multiple chromosomal aberrations in the hawk's beard (metaphase) and lettuce (ana- and telaphase), and also by determining the rate of division in primary mitosis. Parameters measured for the cress included: number of shoots dying during various developmental phases, number of non-fruit bearing seed buds in fertile fruit, number of sterile fruit, frequency of recessive mutants (embryonal deaths and pigment mutants) in the 3 first fruit produced by the main shoot. Seeds were grouped on the basis of whether or not they had been hit by heavy charged particles and the data from the two groups compared with each other and with that of a control group which had not been irradiated.

Data from the cytogenetic analysis of the lettuce showed that irradiated plants had significantly more aberrant cells and cells with multiple chromosomal aberrations than controls, and that seeds hit by carbon ions produced more such mutations than irradiated seeds which were not hit. In addition seeds which were hit showed lower cell division rates. Irradiated

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hawk's-beard cells, regardless of whether they were hit by ions, showed lower mitotic activity than controls. In cress fruitfulness, early death and survival of irradiated cells were not significantly different from controls. But in later stages of development, plants from irradiated seeds were more likely to produce sterile fruit and recessive mutations than non-irradiated plants, regardless of whether seeds had been hit by carbon ions. Cress seeds hit by carbon ions produced significantly more non-fruit bearing seed buds than the irradiated but not hit and control seeds. It was found that total radiation was not large, never exceeding 200 uGy; however, the contribution made by concomitant radiation accounted for up to 80% of the total dose.

The authors conclude that carbon ions engender early and remote genetic effects. Early effects, as reflected by the cytogenetic parameters are a sensitive measure of the effects of heavy charged particles in small doses. Remote effects observed in the cress involve an increased number of sterile fruit, non-fruit bearing seed buds in fertile fruit, and number of recessive mutations. Further study should involve use of "cleaner" bundles of multicharged ions, including some with lower energy (up to 10 MeV/nucleon), i.e., with higher values of linear energy transmission.

Table 1: Results of cytogenetic analysis of lettuce and hawk's-beard seeds irradiated with carbon ions

Table 2: Results of an analysis of cress plants whose seeds were irradiated with carbon ions

Table 3: Dose absorbed by seeds including contribution of concomitant radiation for varying numbers of hits by carbon ions

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

(See also: Adaptation: P480, P497, M105; Aviation Physiology: P496;
Biospherics: BR11; Equipment and Instrumentation: P494;
Neurophysiology: P458)

PAPERS:

P451(11/87)* Artamovova TS, Zakharova TS, Morukov BV, Arzamazov GS, Semenov VYu.

Bioelectric cardiac activity and blood electrolytes in healthy men undergoing 120 days of hypokinesia with head-down tilt.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(6): 24-25; 1986.

[22 references; 6 in English]

Cardiovascular and Respiratory Systems, Bioelectric Cardiac Activity;

Body Fluids, Blood Electrolytes

Humans, Males

Hypokinesia with Head-down Tilt, Long-term

Abstract: In this experiment, 6 healthy men, aged 30-45, spent 120-days undergoing hypokinesia with head-down tilt of -4.5° . EKGs were recorded using 12 standard leads and 3 Nehb (bipolar chest) leads during a baseline period, on days 1, 7, and 28 of hypokinesia with head-down tilt, and then every 2 days until treatment termination, and on days 1, 14 and 25 of a recovery period. Blood was taken from the inside of the elbow 30 minutes after the EKG. Concentration of sodium, magnesium, potassium, total calcium, and ionized calcium in the blood were measured. Although there was some tendency for heart rate and systole to increase, the only statistically significant changes in the EKG parameters involved the T wave, which decreased in amplitude and in the second half of the treatment underwent fluctuations and deformation in some individuals. Taken as a whole, changes in EKG are described as characteristic of mild asymptomatic hypokalemia. During hypokinesia, blood potassium tended to decrease, while blood magnesium and calcium (both total and ionized) tended to increase. Sodium remained stable. There was a positive correlation (0.73-0.75) between T wave changes and concentration of potassium and a negative correlation between T wave behavior and calcium (-0.72- -0.81) and magnesium (-0.80- -0.90) concentrations. Hypokalemia returned to normal rapidly during the recovery period.

Table 1: Changes over time in EKG parameters during 120 days of hypokinesia with head-down tilt

Table 2: Changes over time in concentration of electrolytes in blood serum during 120 days of hypokinesia with head-down tilt

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P467(11/87)* Rumyantsev VV, D'yachenko AI.

The mechanism through which local negative pressure applied to the human body affects central circulation.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 84-86; 1986.

[9 references; 3 in English]

Cardiovascular and Respiratory Systems, Central Circulation; Mathematical Modeling

Humans, Males

Negative Pressure, Lower Body, Local

Abstract: Six healthy male subjects participated in this experiment. After a thorough medical examination, subjects were placed in a head-down tilt position (-15°). After 20 minutes in this position, LBNP, or local negative pressure in the region of the ankles, or abdominal area, increasing from 0 to -60 mm Hg, was applied and their effects on central venous pressure and pressure in the pulmonary artery compared. These parameters were measured using invasive means [not further specified]. It was found that both pressures measured varied as an exponential function of amount of decompression, as described by the following equation:

$$P = P_i + (P_i - P_t) \exp(Kp)$$

where P is the level of central or local pressure; p is the level of decompression; P_i is initial pressure; P_t is the level of terminal pressure (minimum); and K is a coefficient. It required 15-20 seconds for central and local pressure to stabilize after a change in type of decompression. Calf volume stabilized within 1 minute. The authors suggest that changes in central blood pressure determine the amount of blood pooling in the area affected by decompression. It was found that gradual and abrupt increases in decompression had identical effects. Venous capacity was the most sensitive to small amounts of decompression. The authors describe the chain of events arising from local decompression as follows: decompression - transmural pressure - venous volume - volume of circulating blood - central venous pressure, and propose a mathematical model of this sequence.

Table: Comparison of parameters of the model for LBNP and local negative pressure applied to the ankle

| Subject | LBNP | | | Local Decompression | | |
|---------|------------------|------------------------|-----------------------|---------------------|------------------------|-----------------------|
| | P_t , mm Hg | $P_i - P_t$, mm Hg | $100K, (mm\ Hg)^{-1}$ | P_t , mm Hg | $P_i - P_t$, mm Hg | $100K, (mm\ Hg)^{-1}$ |
| A | 0 | 13.64 | 3.43 | 0 | 13.68 | 1.22 |
| B | 0.32 | 15.07 | 4.01 | 7.04 | 8.12 | 2.25 |
| C | 4.35 | 10.63 | 4.94 | 8.91 | 4.15 | 4.06 |
| D | 1.78 | 10.44 | 6.71 | 5.4 | 4.45 | 2.07 |
| E | 4.45 | 18.06 | 8.00 | 6.72 | 6.28 | 3.35 |
| F | 3.96 | 14.15 | 3.81 | 9.1 | 6.07 | 2.21 |

Figure: Change in central venous pressure and calf volume as a function of local decompression to the ankles

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P481(11/87)* Yarullin KhKh, Artamanova NP.

Responses to [literally: characteristics of] the atropine test in individuals varying in age.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1):37-42; 1987.

[13 references; none in English]

Cardiovascular and Respiratory Systems, EKG Parameters
Humans, Males, Age Differences
Atropine

Abstract: A test involving subcutaneous injection of atropine sulfate (1.0 ml 0.1% solution) was performed on 47 males varying in age. Group 1 contained 17 men aged 25-39, group 2 contained 25 men aged 40-49, and group 3 contained 5 men aged 50-59. At the same time EKG was recorded using standard, or in 3 cases Nehb (bipolar chest) leads. Recording began before the atropine injection, and continued every 3 minutes during the half hour after injection and every 5 minutes during the half hour after that. Parameters measured included duration of cardiac cycle RR (as well as corresponding heart rate per minute), PQ interval and electric systole QT, actual and required systolic index in percent, and amplitude of R and T waves.

Heart rate data showed that most individuals react to atropine in 2 phases: slowing in the first 25-30 minutes and quickening subsequently. The first phase involves bradycardia and is associated with vagal stimulation; the second involves tachycardia and results from blockade of the cholinergic receptors. Effects of the injection were similar in all groups; however, in older subjects bradycardia was diminished, second phase tachycardia lasted longer, and the electric systole response to increased heart rate was less pronounced. Younger subjects were more apt to develop arrhythmia in response to atropine. The authors attribute these differences to slowing of biological processes with age.

Table 1: Changes in mean values of heart rate (per minute) in men varying in age in response to atropine

Table 2: Changes in mean values in EKG parameters in men varying in age in response to atropine

Figure: EKG for subject V., 32 years old, in D, A, and I Nehb leads

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P486(11/87)* Kazakova RT, Krotov VP, Giryayeva IO/

Central hemodynamics in monkeys in a postoperative period as a function of preoperative living conditions.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 58-60; 1987.

[4 references; 1 in English]

Cardiovascular and Respiratory Systems, Central Hemodynamics, Contractile and Pumping Function

Primates, Rhesus Monkeys

Immobilization; Operational Medicine, Surgery, Electrode Implantation

Abstract: This experiment investigated hemodynamic effects of certain preflight living conditions of primates being prepared for flight on a biosatellite. These conditions are: confinement in a primate chair, and surgery, e.g., to implant transmitters and electrodes. A total of 26 rhesus monkeys were divided into 3 groups. All groups were operated upon to implant electrodes and transmitters above the carotid artery. The first group (n=6) spent the preoperative period in an open air cage; the second group were confined in a primatological chair for 24 hours a day for 1.5-2 months before the operation; the third group (n=8) spent most of the same period confined in chairs but were allowed a day in an open air cage once or twice a week. Central hemodynamic parameters were measured using echocardiography and electrocardiography pre- and post-operatively. Group 1 was studied on days 3, 10, and 20 after the operation; group 2 on days 10, 15, and 20-25; and group 3 on days 3 and 10. Cardiac parameters studied included: heart rate, stroke volume, stroke volume index, minute volume, cardiac index, terminal diastolic volume of left ventricle, terminal systolic volume of left ventricle, ejection fraction, and decrease in anteroposterior dimension of the left ventricle during systole.

One day before the operation the parameters indicative of left ventricle pumping function were significantly lower for group 2 animals than for group 3. There were no differences between groups 1 and 3 in these parameters, suggesting that as little as 1-2 days per week of free movement are sufficient to prevent effects of immobilization of cardiac pumping function. After the operation, parameters of animals in group 1 returned to normal by day 3. Animals in group 3 still showed disruptions in function (depressed stroke volume, stroke index, minute volume, terminal diastolic volume, ejection fraction, ventricle size and increased heart rate [only stroke volume is significant]) compared to baseline on days 10-15 after surgery. By days 20-25 these parameters had returned to normal. In group 3, only heart rate and minute volume were altered on days 3 and 10 post-operation, while parameters of contractile function were at baseline level. No group displayed changes in size of left auricle, width of intraventricular partition, or posterior wall of the left ventricle. The authors conclude that initial state has a significant influence on how surgery affects intracardiac hemodynamics. Short periods of normal activity interspersed with longer periods of hypokinesia appear sufficient to normalize the circulation system and ensure adequate recovery from surgery. This method of maintaining monkeys preflight is recommended, and it is suggested that baseline cardiac parameters be measured no sooner than two weeks after an implantation operation.

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Table 1: Parameters of central hemodynamics in group 1 monkeys at varying intervals after surgery

Table 2: Parameters of central hemodynamics in group 2 monkeys before and after surgery

Table 3: Parameters of central hemodynamics in group 3 monkeys at varying intervals after surgery

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P487(11/87)* Simonov LG, Saribekyan AS.

[Properties] of pulsation volumes and pressures in response to changes in "reserve spaces" in the skull.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 61-66; 1987.

[15 references; 3 in English]

Cardiovascular and Respiratory Systems, Intracranial Blood Flow and Pressure; Operational Medicine, Ultrasound Scanning of the Brain Humans, Neurosurgical Patients; Primates, Rhesus Monkeys Neurophysiology, Cerebrospinal Fluid, Reserve Spaces

Abstract: The goal of this work was to evaluate parameters of pulsations in volume and pressure when the level of intracranial pressure changes. Invasive methods were used to study intrabrain, intracranial subdural, and cerebrospinal pressure, and local brain blood flow in neurosurgical patients with various kinds of brain disorders. The bodies of rhesus monkeys were used to verify current ideas about the "reserve spaces" in the cerebrospinal system. Ultrasound scanning was used to find parameters of intracranial blood and fluid dynamics in neurological patients. In some subjects pulsed damping of ultrasound was used to study mechanical displacements of the walls of the lateral cerebral ventricle in response to intracranial blood pulsations.

Studies of the monkeys' bodies determined that subdural pressure did not vary linearly with the amount of physiological solution injected ventriculally, but depended on the initial volume. Previous work has shown that when the function of pressure on volume is determined, the modulus of elasticity must be taken into account. As intracranial pressure increases to a certain point, the modulus of elasticity remains relatively constant; however after this point elasticity increases virtually linearly with pressure. The point where the relationship between pressure and elasticity changes represents the point where the reserve space in the cerebrospinal system is exhausted. Ultrasound studies showed that as cerebrospinal pressure increases to 220 mm H₂O, pulsed damping of ultrasound increases, after which it decreases. Again, the existence of reserve space is taken to be the cause of this discontinuity. It is considered possible that the inflection point occurs when cerebrospinal pressure equals tissue pressure. As cerebrospinal pressure increases initially, the reserve space in the system decreases and the pulsation of blood in the brain tissue is almost completely transmitted to the walls of the ventricle. After maximum pressure has been reached, further increases in cerebrospinal pressure in the skull increase tissue pressure in the brain as well, limiting the capacity of the ventricle wall to shift; the pulsation parameter then starts to decrease. This points to exhaustion of compensatory mechanism (reserve spaces) in the cerebrospinal system which provides pulsed flow of cerebrospinal fluid between the brain and spine. However, the reserve capacity of the intrabrain venous system are still available. The point where this reserve is exhausted is identified with the inflection point in the curves of change in subdural pressure divided by subdural pressure and duration of anacrotic phase of pulsation divided by period as functions of increasing subdural pressure. These inflection points occur at a pressure of about 400-500 mm H₂O. After this point blood flow in the brain may be deficient. The authors argue that by examining patterns of change in ultrasound parameters as intracranial pressure increases, one can determine

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if the cerebral spinal system or venous system is compensating for increased pressure, and how close to the critical point this pressure is. Thus ultrasound scanning of the brain has high potential for noninvasive diagnosis of parameters of the cerebrospinal system.

Table: Volumes and pressures of components of the blood and cerebrospinal fluid systems

Figure 1: Elasticity as a function of subdural pressure in the cerebrospinal system

Figure 2: Pulsations in volume and pressure at varying levels of intracranial pressure

Figure 3: Changes in local brain blood flow with changes in intrabrain pressure changes in neurosurgical patients after surgery

Figure 4: Range of pressures in the cranial cavity and their characteristic patterns

CARDIOVASCULAR AND RESPIRATORY SYSTEMS

P488(11/87)* Khodos BA, Gabinskiy VL.

A comparative study of central hemodynamics, myocardial contractility, and tension in the left ventricle wall in athletes and [cardiac] patients.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 66-71; 1987.

[18 references; 7 in English]

Cardiovascular and Respiratory System, Central Hemodynamics, Myocardial Contractility, Ventricular Wall Tension; Operational Medicine, Diagnosis, Latent Cardiac Insufficiency
Humans, Males, Athletes, Patients, Ischemic Heart Disease, Hypertension
Physical Exercise

Abstract: The purpose of this study was to increase understanding of the cardiac effects of rigorous athletic training and improve diagnosis of latent cardiac insufficiency. Measurements were made on 15 world-class handball players, aged 20-30; 20 patients with ischemic heart disease being treated at a hospital; 20 patients with high blood pressure identified through routine screening (neither group of patients showed signs of circulatory deficiencies; patients were 40-49); and two control groups of healthy nonathletes, one group aged 20-30 and the other 40-49. Echocardiography was performed and the following parameters measured: terminal diastolic and systolic volume, stroke volume, width of anterior wall of the left ventricle, width of interventricular septum, thickening of the anterior wall of the left ventricle, thickening of the interventricular septum, myocardial weight, ejection fraction, decrease in area of ventricle cavity, rate of contraction of circular fibers of the myocardium and rate of relaxation of the anterior wall of the left ventricle. Meridional and circular tension of the left ventricle wall were calculated by formula. Parameters were measured before exercise and in the first minute after graded exercise on a bicycle ergometer. Exercise was terminated when heart rate reached 80-90% of maximal, which was calculated by formula.

At rest, athletes and ischemic patients showed elevated terminal diastolic and systolic blood pressure, and patients with high blood pressure showed elevations in terminal diastolic blood pressure, stroke volume, and minute volume. The athletes displayed the highest values for thickness and thickening of anterior wall of the left ventricle, thickness and thickening of the interventricular septum, and myocardial weight. The subjects with high blood pressure also showed values of ventricular thickness and myocardial weight above control level, but these values were less than for athletes. No differences were found in the index of contractility for any groups. The indices of meridional and circular tension of the ventricle wall were the most informative; these were lowest for athletes and highest for patients. Differences among groups were more pronounced after exercise. In the athletes terminal diastolic volume remained higher than that of control, but terminal systolic volume dropped to control levels, while stroke volume further increased relative to control. For both groups of patients, terminal systolic volume increased, while that of controls decreased. Stroke and terminal diastolic volumes were no different than controls. Minute volume increased in all groups and was higher in athletes and patients than in controls. Contractility parameters were lower for those with ischemic heart disease, while those of the other groups were no different. Ischemic patients differed from the other groups in that ejection fraction, contraction of ventricular cavity, and contraction of

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circulatory fibers did not increase after exercise. These data are interpreted as showing that dilation and hypertrophy are different in athletes than in patients suffering from high blood pressure and, particularly, ischemic heart disease. For athletes, these characteristics represent a reserve which can lead to hyperfunction when the myocardium is mobilized inotropically. Those with ischemic heart disease show latent "inotropic insufficiency," which prevents them from increasing myocardial contractility in response to physical exertion and thus leads to hidden cardiac insufficiency. The computed parameters of meridional and circulatory tension on the ventricular walls distinguish between athletes, controls, and patients, and are promising as indicators of hidden inotropic insufficiency, especially as they do not require possibly dangerous exertion.

Table 1: Baseline values of parameters indicative of central hemodynamics and myocardial contractility in athletes, patients suffering from ischemic heart disease and high blood pressure, and healthy individuals of the same ages

Table 2: Parameters indicative of central hemodynamics and myocardial contractility in athletes, patients suffering from ischemic heart disease and high blood pressure, and healthy subjects of comparable age before and after physical exercise

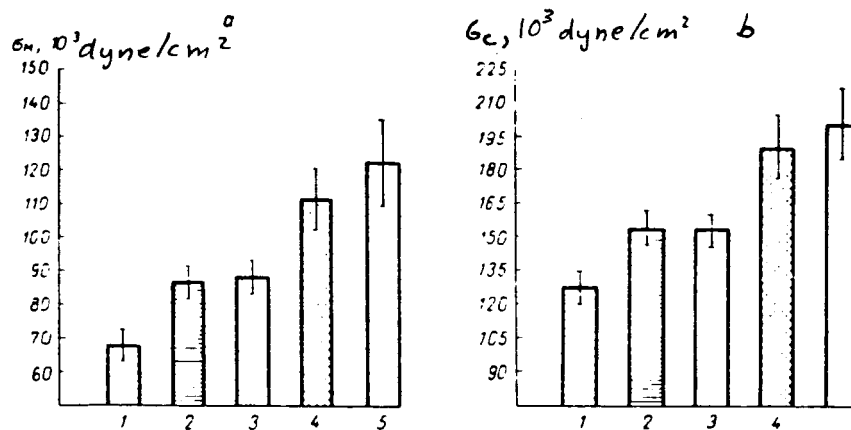


Figure 1: Terminal systolic meridional (a) and circulatory (b) tension of the walls of the left ventricle

1 - athletes; 2 - control, aged 40-49; 3 - control, aged 20-30; 4 - patients with high blood pressure; 5 - patients with ischemic heart disease

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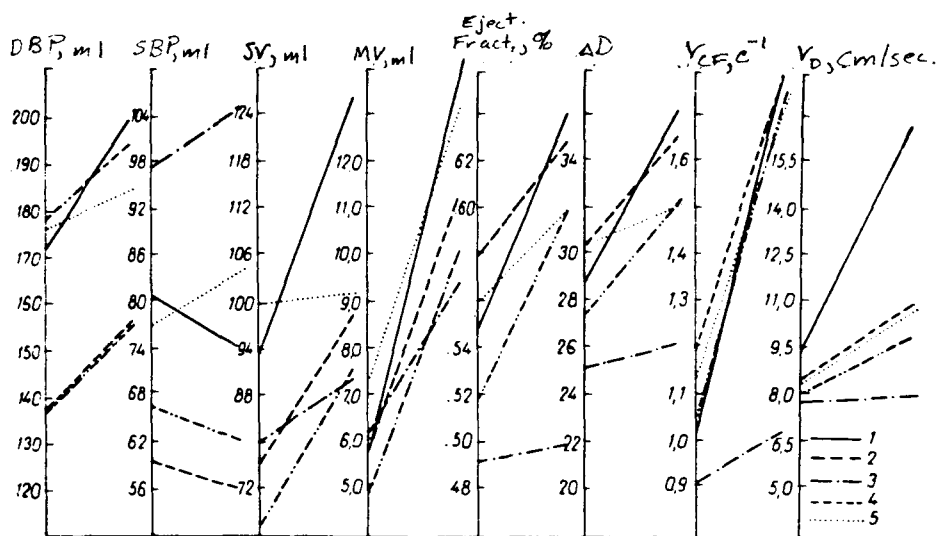


Figure 2: Changes in parameters indicative of central hemodynamics and myocardial contractility before and after physical exercise
 1 - athletes; 2 - control, 20-30; 3 - control, 40-49; 4 - patients with ischemic heart disease; 5 - patients with high blood pressure

DEVELOPMENTAL BIOLOGY

PAPER:

P482(11/87)* Shakhmatova Yel, Lavrova YeA, Natochin YuV, Serova LV, Denisova LA.

Concentration of fluid and electrolytes in pregnant rats and their offspring after flight in the "Cosmos-1514" biosatellite.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 42-47; 1987.

[15 references; 7 in English]

Developmental Biology; Body Fluids, Fluid and Electrolyte Balance
Rats, Pregnant, Fetus, Neonate
Space Flight, Cosmos-1514

Abstract: In this study 4 month old pregnant Wistar rats were flown on the "Cosmos-1514" biosatellite between days 13-18 of their pregnancies. Synchronous and vivarous control groups were used. Some subjects were sacrificed and dissected on day 18 of pregnancy, the mothers' bone tissue (tibia), skin, kidney, and liver samples were studied, as well as the entire fetus and placenta. The remaining mothers were allowed to complete their pregnancies until natural birth and their offspring were studied on days 1, 15 and 30 after birth. In order to determine water content and dry weight of the fetuses, placentas, organs of the newborn rats, and samples of organs of mature rats, they were weighed immediately after isolation and then dried to constant weight, placed in HNO_3 bath until the organic substance had completely dissolved, after which the acid was evaporated off, and the samples washed in distilled water. Concentrations of sodium, potassium, calcium and magnesium were measured.

The body weights of flight fetuses were 10% lower than those of synchronous controls. Dry body weight was 12% below that of synchronous counterparts, indicating that space flight factors retard the formation of organic matter. The amount of retardation is said to be 5 hours, corresponding to 5 days for a human. Since there was significant difference in these parameters between synchronous (exposed to all space flight factors except weightlessness) and vivarous controls, the effect can be attributed to weightlessness per se. The relative water content of the fetal bodies was not at all depressed by their exposure to space; indeed it exceeded that of controls by 6%, another sign of retarded development. Retardation is estimated as 17 hours, equivalent to 18 days in human embryogenesis. On the other hand, concentrations of sodium, potassium, calcium, and magnesium in the bodies of the flight fetuses were appropriate to their calendar age and did not differ from those of controls.

The wet and dry weights of the placentas were also reduced in the mothers of these animals. While the water content of the placentas was no different from that of controls, they contained more sodium and less potassium than those of animals who carried their pregnancies to term on Earth. Little weight gain occurred in the pregnant rats while in space, while comparable controls gained considerable weight. This difference cannot be attributed to differences in food intake, nor to weight

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of the litter. Livers of space mothers weighed considerably less than those of controls, while kidney weights were comparable. Concentration of electrolytes in the skin and bone tissue was virtually unchanged by space flight. However the liver displayed a substantial decrease in calcium and a moderate increase in sodium, and the kidneys displayed decreases in sodium, potassium, and calcium. Since the fluid-electrolyte composition of the fetuses was more stable than that of the mothers, the authors conclude that the mechanism for maintaining mineral homeostasis in the fetus functions independently of the mother. One-day-old rats of mothers flown in space showed no differences in fluids and electrolytes in the liver, heart, or skin. Kidney weights of flight animals were greater and concentration of electrolytes lower than that of control counterparts. No differences from controls were found in 15-day- or 30-day-old flight animals, testifying not only to their normalcy but to the normalcy of the milk of mothers flown in space. These data indicate that fluid-electrolyte homeostasis of developing fetuses was only slightly influenced by weightlessness and whatever deviations did occur rapidly returned to normal.

Table: Concentration of fluid (in g per 1 g weight) and electrolytes (in mequiv per 1 g weight) in dry weight of 18-day-old rat fetuses

| Parameter | Flight n=9 | Group | |
|-----------|---------------|----------------------------|--------------------------|
| | | Synchronous Control n=9 | Vivacious Control n=9 |
| | | Fetus | |
| Fluid | 0.905 | 0.900 | 0.900 |
| Sodium | 82.9 | 81.4 | 85.4 |
| Potassium | 60.4 | 58.6 | 59.9 |
| Calcium | 19.9 | 21.6 | 22.9 |
| Magnesium | 13.0 | 12.4 | 14.9 |
| | | Placenta | |
| Fluid | 0.855 | 0.855 | 0.853 |
| Sodium | 72.5* | 62.8 | 67.0 |
| Potassium | 56.7* | 63.6 | 63.6 |
| Calcium | 5.6 | 5.9 | 7.6 |
| Magnesium | 10.3 | 10.2 | 11.0 |

* difference between flight and synchronous control significant at $P < 0.001$

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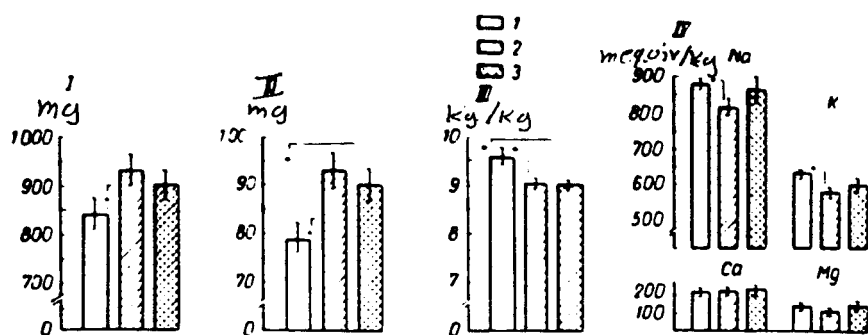


Figure 1: Concentration of dry substance, fluid and electrolytes in 18-day rat fetuses

Here and in Figure 2 the ordinate represents I: weight in mg; II: dry weight in mg; III: H_2O in kg per g dry weight; IV: concentration of electrolytes in mequiv per g dry weight; 1 - flight fetuses; 2 - synchronous control; 3 - vivarous control; * $p < 0.05$ • $p < 0.01$

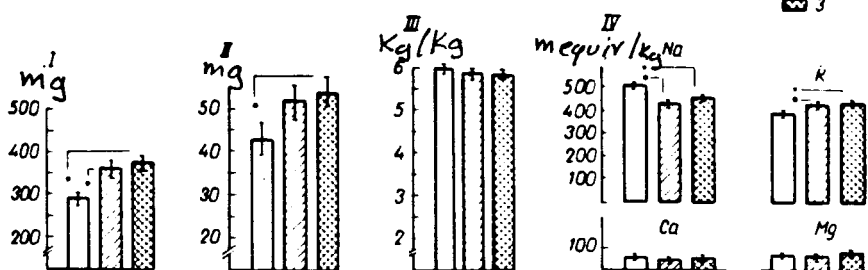


Figure 2: Concentration in dry substance of fluid and electrolytes in the placentas of rats on day 18 of pregnancy

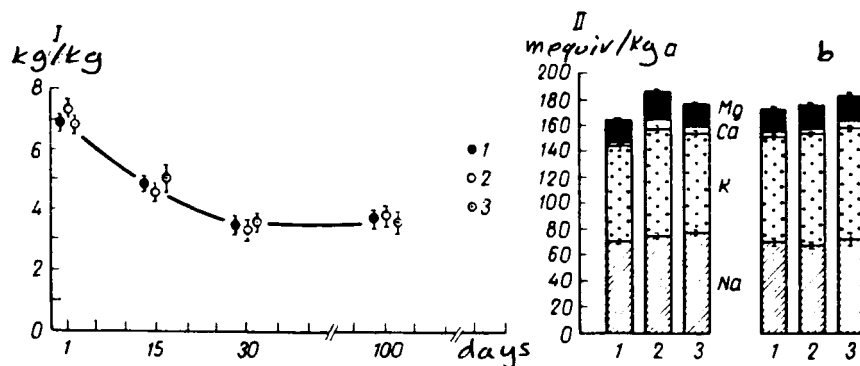


Figure 3: Concentration of fluid (I, in kg/kg dry weight) and electrolytes (II, in mequiv/kg wet weight) in the kidneys of rats varying in age
Abscissa: 1 - pregnant animals exposed to weightlessness and their offspring; 2 - synchronous control; 3 - vivarous control. a-age=1 day; b-age=15 days.

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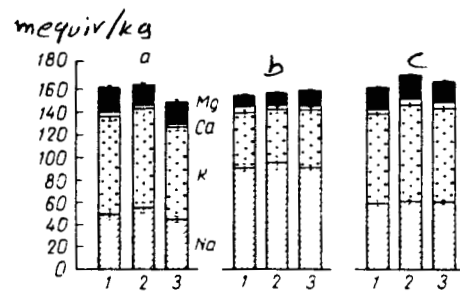


Figure 4: Concentration of electrolytes (in mequiv/g wet substance) in the liver (a), skin (b), and heart (c) of 1-day-old rats

1 - flight group; 2- synchronous control; 3 - vivarous control.

ENDOCRINOLOGY

(See also: Gastrointestinal System: P455; Nutrition: P475)

PAPERS:

P457(11/87)* Krasnov IB, Babichenko II, Afonin BV, Pankova AS.

Morphological and biochemical analyses of certain organs and tissues in rats after 30 days of exposure to increased gravity of 1.1- and 2-g.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6):

51-58; 1986.

[27 references; 19 in English]

Endocrinology, ACTH, Angiotensin, Aldosterone, Renin, Thymus, Adrenal Gland; Neurophysiology, Cerebellum, Vestibular System

Rats, Males

Artificial Gravity, Centrifugation

Abstract: In this experiment male SPF rats were either centrifuged in cages attached peripherally on a centrifuge (equivalent to 2-g), centrifuged in a cage attached to the central portion of a centrifuge (equivalent to 1.1-g) or kept in non-centrifuged cages for 30 days. The centrifuge rotated at a rate of 33.3 rotations/minute. Each cage contained 10 animals. Animals were exposed to 12 hours of light and 12 of darkness per day, and consumed the same diet. On day 30 of rotation, and days 2 and 7 of a recovery period, 7 of the animals in each group were weighed and then sacrificed. Ultrathin sections of the nodulus of the left half of the vermis cerebelli were examined with an electron microscope. Concentrations of ACTH, angiotensin, and aldosterone, as well as renin activity were measured in combined plasma by radioimmune assay. The thymus and adrenal glands were weighed and the latter were fixed, sliced, and stained.

Microscopic examination revealed no pathological changes in the brain or organs of the chest or abdominal cavities. After 30 days of centrifugation, animals in both experimental groups showed a tendency to gain less weight than controls, with the tendency more pronounced in the 2-g group. Weight of the 2-g animals continued to drop after centrifugation stopped and recovered more slowly than that of the 1.1-g group. No significant effects were noted on the weight of the thymus and adrenal glands; nor were morphological changes noted in these glands. On day 30 of centrifugation, plasma ACTH concentration was depressed to the same degree in both centrifugation groups; however, the level had recovered by day 7 post treatment in the 1.1-, but not the 2-g group. The exact mechanism underlying this effect is unclear. On day 30 of rotation, rats in the 2-g group showed significantly increased concentrations of plasma angiotensin 1 and aldosterone, and a tendency for renin activity to increase. On day 2 post treatment angiotensin, aldosterone and renin activity were higher than control levels for both centrifugation groups, but more so for the 2-g subjects. Levels of these hormones dropped on day 7 post-treatment in both groups. Examination of the ultrastructure of the granular layer of the cerebellar nodulus cortex showed that in control animals the mossy fiber terminals are located in the central portion of the glomerulus, and contain synaptic vesicles grouped in the area of the

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synapses, and intact mitochondria with an electronically dense matrix and multiple cristae. Rats centrifuged at 1.1-g displayed changes in the ultrastructure of the mossy fiber terminals suggesting a state of excitation. There were more synaptic vesicles, and edged and large light vesicles. Pre- and post-synaptic membranes showed high electron density, as did the post synaptic thickening; the width of the synaptic gaps increased, as did the electron density of their matrix. There was a lightening of the mitochondrial matrix and shortening of its cristae. There were 3 types of changes in the mossy fiber terminal ultrastructure in rats centrifuged at 2-g for 30 days. In the area of the terminals, the ultrastructure was typical of a state of extreme excitation, leading in a number of cases to blockage of synaptic transmission: sharply increased density of synaptic vesicles in the terminals, edged vesicles, mitochondria with light cavities and altered cristae, and presynaptic zones without concentration of synaptic vesicles. The ultrastructure of another portion of the mossy fiber terminals showed signs of "light" degeneration: lightened axoplasm; decrease in number of synaptic vesicles which clustered in groups of 8-12, 8-12 nm from the presynaptic membrane; and altered mitochondria. A third group of mossy fiber terminals showed signs of "dark" degeneration, increased electron density of axoplasm because of high density of synaptic vesicles. The central portion of these terminals contained mitochondria with an electron matrix and shortened cristae. Synaptic contacts were in an inactive state. Since the ultrastructure of mossy fiber terminals reflects the functional activity of neurons of the vestibular ganglia receiving information from receptor cells of the otolith, these data suggest that 30 days of exposure to 1.1-g produces a state of excitation in the system of utricular receptor cells -- vestibular ganglia neurons, while exposure to 2-g produces excessive stimulation. Two days after termination of centrifugation, ultrastructure of rats in the 1.1-g group showed signs of normalization, while that of rats in the 2-g groups still indicated states of "light" and "dark" degeneration. Seven days after treatment termination, ultrastructure of both experimental groups returned to normal. The authors conclude that changes in the state of the renin-angiotensin-aldosterone system and in the activity of the utricular receptor cell -- vestibular ganglia neuron noted on the second day after return to normal gravity are similar in direction to those noted during adaptation to weightlessness. Therefore, it is possible to use the former data for analysis of certain effects of weightlessness on mammals.

Table 1: Changes in weight of rats after exposure to increased gravity and return to normal gravity

Table 2: Weights of thymus and adrenal glands of rats after exposure to increased gravity and return to normal gravity

Table 3: Renin activity, and amount of angiotensin 1, aldosterone, and ACTH in blood plasma of rats in increased gravity and after return to normal

Figure 1: Granular cell of the cerebellar nodulus cortex in rats

Figure 2: Terminals of mossy fibers in the granular layer of the cerebellar nodulus cortex in rats

Figure 3: Terminals of mossy fibers showing early "dark" degeneration

P461(11/87)* Klimovskaya LD, Kokoreva LV.

Reactivity of the sympathetic adrenal system and exercise tolerance under repeated exposure to a constant magnetic field.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 70-72; 1986.

[12 references; 2 in English]

Endocrinology, Sympathetic Adrenal System; Physical Work Capacity

Rats, Males

Radiobiology, Magnetic Field, Constant; Physical Exercise

Abstract: This experiment utilized a total of 170 male rats. Experimental rats were exposed to a constant vertical magnetic field with inductance of 1.67 T for 3 hours a day for up to 30 days. Control rats were not exposed to the field. Additionally, experimental rats (and some control rats) were forced to swim with an affixed weight equal to 10% body weight in water at 32°C. For the experimental animals these sessions occurred immediately after days 1, 5, 15, and 30 of exposure to the magnetic fields and 1 day after the last exposure. Physical work capacity was identified as the length of time each animal swam before reaching total exhaustion. After exercise sessions rats were apparently sacrificed and their adrenal glands removed. Concentrations of adrenaline and norepinephrine in the adrenal gland and blood plasma were determined using fluorometry.

Previous work has shown that exposure to a constant magnetic field increases the amount of adrenaline in a rat's blood, peaking at 15 days, and that adrenaline level returns to normal within a week after the last exposure. After the exercise animals not exposed to the magnetic field showed a significant increase in the amount of adrenaline in the blood, but effect of exposure to the magnetic field on this response depended on exposure duration. Rats compelled to exercise after 1-15 days of exposure had adrenaline levels in the blood higher than those associated with the effects of either factor in isolation. Rats exposed to the field for 30 days showed blood adrenaline concentration lower than those associated with either factor alone. During the entire exposure period concentration of catecholamines in the adrenal gland were normal or slightly elevated. This indicates that during the initial period of exposure, increased secretion of adrenaline into the blood in response to exercise is compensated by enhanced resynthesis. The decreased secretion of adrenaline in response to exercise after 30 days of exposure to the field cannot be explained by exhaustion of the gland's capacity. It is, however, possible that repeated exposure decreased the sensitivity of the sympathetic adrenal system. The two phases noted in secretion of adrenaline to exercise during exposure to a magnetic field are paralleled by phases of response of work capacity, which increased substantially after 1-15 days of exposure and then dropped after 30 days of exposure. However, work capacity in the rats exposed for the full period did not drop below control levels, even though blood adrenaline levels were below those of rats exposed to exercise alone.

Table: Effects of physical exercise on the amount of catecholamines in the adrenal glands of rats exposed to a constant magnetic field of 1.6 T

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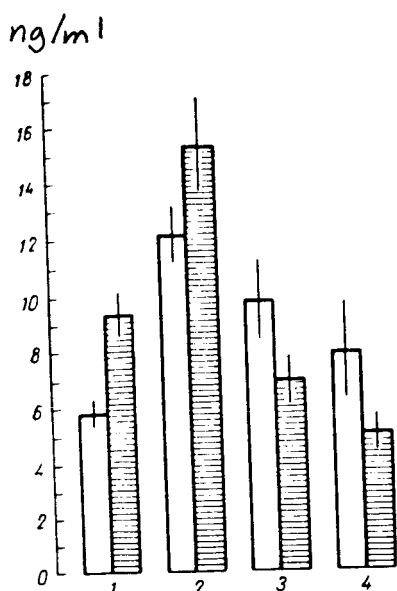


Figure 1: The effect of physical exercise on the amount of adrenaline in the blood of control rats and rats exposed for 3 hours daily to a constant magnetic field with inductance of 1.6 T

1 - control; 2 - 1-15 day exposure; 3 - 30-day exposure; 4 - 1 day after 30th exposure. White bars -- before physical exercise; cross-hatched bars -- after physical exercise. Ordinate -- quantity of adrenaline in ng/ml

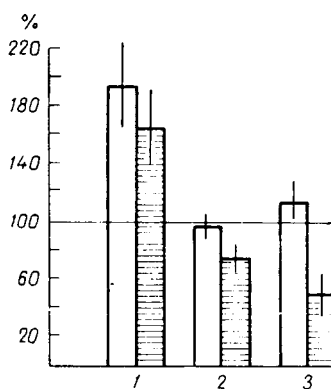


Figure 2: Change (in % of control) in maximum duration of swimming and quantity of adrenaline in blood after swimming in animals exposed for 3 hours daily to a constant magnetic field with inductance of 1.6 T

1 -- 1-15 days of exposure; 2 -- 30 days of exposure; 3 -- 1 day after 30th exposure. White bars -- swimming time cross-hatched bars -- quantity of adrenaline in the blood after swimming.

ENDOCRINOLOGY

P477(11/87)* Makarovskiy VV, Reznikov YuP, Khalangot AF, Zinkovskaya SA.
**Variations in hormones, sugar, and electrolytes in the blood as shown by
biochemical indicators in men undergoing hypodynamia.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 21-27; 1987.

[17 references; 9 in English]

Endocrinology, Hormones, Aldosterone, Testosterone, Hydrocortisone, T3, T4;

Body Fluids, Blood Electrolytes; Metabolism, Blood Sugar

Humans, Men, Age Groups

Hypodynamia; Life Support Systems, Hermetically Sealed Quarters; Physical
Exercise

Abstract: In this study, 72 healthy men lived for 30 days in hermetically sealed quarters with constant temperature (20-24°C), air flow (0.1-0.3 m/sec), relative humidity (70-80%), concentration of CO₂ (0.3-0.6%), and concentration of O₂ (19-20.8%). The men were divided into 3 groups on the basis of age. Members of group 1 (n=16) were 19-21, of group 2 (n=26) 25-43, and of group 3 (n=30) 48-59. Group 3 was further divided into two subgroups (n=10 each). Group 3b engaged in a daily exercise program from days 7-30 of seclusion, while group 3a did not. Venous blood was taken at 8:00-9:00 a.m. on an empty stomach during 4 periods: before seclusion (period 0), on days 7-8 of seclusion (period 1), on days 14-15 of seclusion (period 2) and days 29-30 (period 3). [Note: preceding procedure not specified in current paper, taken from earlier paper in Digest Issue 10, P426(10/87)* page 59.] Concentration of hormones, hydrocortisone, aldosterone, testosterone, 3,5,3'-triiodothyronine (T3), and thyroxine (T4) were determined using radio immune assay. Concentrations of sugar, potassium, sodium, and chlorides in blood serum were also measured.

In the baseline (0) period, significant differences were found among the age groups in concentrations of aldosterone, testosterone, T3, sugar, potassium, sodium, and chlorides. Over the course of the hypodynamia period, levels of hydrocortisone changed in a cyclic manner in all groups, with the highest level noted at the end of period 1 and the lowest at the end of period 2. Fluctuations in level of aldosterone were also noted, but those in the oldest age group differed from those in the other two. Concentrations of testosterone decreased, increased, and then decreased again in all groups. In the youngest group T3 continued to drop throughout hypodynamia; in the middle group this level dropped initially and then maintained the new level; in the oldest group initial concentration rose and then dropped in the exercise subgroup, but not the other, and T3 eventually dropped to baseline level. Concentration of T4 showed less variation than T3 in all groups. In the two younger groups, blood sugar initially dropped, rose, then dropped again. In the older group, blood sugar dropped, stabilized, and then rose. Potassium dropped initially in all groups and then rose in groups 1 and 3a (no exercise). In the youngest group sodium decreased throughout the experiment. In the middle group it increased and then dropped. In the oldest group differences in sodium concentration were slight. In the two youngest groups changes in chlorides paralleled those in sodium. In the older nonexercising group, chlorides increased by the end of period 2 and then dropped. In the older exercising group chloride levels were stable. Correlation coefficients between concentrations of pairs of substances measured were computed separately for each group. It was found that correlations between the same pairs of

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substances varied in magnitude and even sign for different groups. In general, the older exercising group showed correlations between concentrations of substances which were attenuated compared to those of the nonexercising group.

The authors conclude that the results show that during 1 month's adaptation to hypodynamia in a hermetically sealed environment, no stabilization of biochemical parameters occurs. Only in older subjects who performed regular exercises did many of the biochemical parameters of the blood (hydrocortisone, aldosterone, testosterone, T3, chlorides, and to a lesser extent T4, sugar and potassium) approach baseline values. According to the theory of Parfenova, adaptation to hypodynamia reaches the third stage of adaptation, characterized by stabilization of functional parameters (e.g., pulse rate) only during days 30-60 of exposure.

Table 1: Concentration of hormones, sugar and electrolytes in blood serum in healthy males in a baseline period

Table 2: Changes in biochemical parameters of blood in healthy males living in a closed life-support environment

Table 3: Correlation coefficients between biochemical parameters of blood in healthy males living in a closed life-support environment

ENZYMOLGY

(See also: Nutrition: P475)

PAPER:

P495(11/87)* Serebrovskaya TV, Krasnyuk AN, Fedorovich VN.

Isoenzyme composition of lactate dehydrogenase in the blood in humans in response to repeated exposure to acute hypoxia and its relationship to level of physical work capacity.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 87-89; 1987.

[20 references; 5 in English]

Enzymology, Lactate Dehydrogenase, Isoenzyme Spectrum

Humans, Males

Adaptation, Hypoxia; Physical Exercise

Abstract: Subjects in this experiment were 8 healthy males, aged 20-28, varying in physical fitness, and with V_{O2max} at exercise to exhaustion varying between 28-70 ml/min/kg. Subjects were conditioned over 5 days to hypoxia by daily 20-minute sessions of breathing a hypoxic mixture with 10% O_2 . Minute respiratory volume was recorded with a volumeter, and gas analyses performed on a mass spectrometer. Gas exchange was determined using a Douglas-Holden curve, and sensitivity to hypoxia through reverse breathing of CO_2 . Blood was taken from the median cubital vein before and after the series of training sessions. Erythrocytes were isolated, washed, and subjected to hemolysis. The isoenzyme spectrum of lactate dehydrogenase in the hemolysate was determined by electrophoresis 1 hour after rapid thawing. Densitometry was performed.

Results showed that conditioning to hypoxia gives rise to changes in the general activity of lactate dehydrogenase in a hemolysate of human blood as well as in its isoenzyme spectrum. Overall enzyme activity increased by 34%. There were increases in the activity of all enzyme fractions, but the only significant changes occurred in the sum of aerobic fractions (increase of 29%). Although anaerobic fraction activity increased by 121%, substantial individual differences caused this to fall short of statistical significance. Proportion of aerobic fractions in total concentration of lactate dehydrogenase remained virtually unchanged while that of anaerobic fractions increased by a factor of more than 2. As subjects were conditioned to hypoxia there was less increase in ventilation in a steady state, and less pronounced decrease in oxygen consumption. Oxygen consumption coefficient increased from 22.1 on the first day to 29.4 on the fifth day. There was a reliable correlation between changes in oxygen consumption under hypoxic conditions and changes in lactate dehydrogenase activity: the greater the increase in lactate dehydrogenase activity due to hypoxic conditioning, the smaller the decrease in V_{O2} under exposure to a hypoxic medium. The study also revealed a significant positive association between an individual's initial level of lactate dehydrogenase activity and his physical work capacity and maximal aerobic productivity. Individuals with higher initial levels of physical work capacity showed lower increases in activity of aerobic fractions and greater increases in anaerobic fractions attributable to hypoxic conditioning. An inverse relationship was noted between ventilatory sensitivity to hypoxia and increase of anaerobic fractions resulting from conditioning.

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Figure 1: Change in respiratory minute volume and oxygen consumption during conditioning to hypoxia

Figure 2: Correlations between physical work capacity, maximum oxygen consumption, sensitivity to hypoxia and isoenzyme composition of lactate dehydrogenase in erythrocytes

EQUIPMENT AND INSTRUMENTATION

(See also: Nutrition: P475; Operational Medicine: CR5; Perception: P500)

PAPER:

P494(11/87)* Drozhzhin VM.

Automation of research on operator performance.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 78-80; 1987.

[2 references; none in English]

Equipment and Instrumentation, Automated Research System

Humans, Operators

Human Performance, Tracking; Cardiovascular and Respiratory Systems, EKG
Parameters

Abstract: This paper describes a microcomputer-based system for automating physiological studies of operator performance. The system consists of 4 microcomputers connected via a parallel interface. The hierarchical computer system has 2 levels: the lower level involves 3 computers which perform preliminary processing of cardiograms (with bipolar chest leads), plethysmograms, pneumotachograms, systolic pressure in the earlobe, myograms, and also data on gravitational force; at the upper level is a single computer which performs integrated evaluation of the state and work capacity of the operator, and also receives and processes signals related to body temperature, and tracking performance. Preliminary processing of physiological curves on-line include parameters such as: identification of R-R intervals; computation of heart rate and of an arrhythmia index; display of a rhythmogram on the screen; indication of extrasystole; computation of ejection time, stroke and minute volumes; respiratory rate and minute volume; systolic pressure in earlobe; mean amplitude of myogram over set time intervals; calculation of discrepancies and evaluation of work capacity for tracking task; computation of latency to respond to a light stimulus; calculation and evaluation of skin and rectal temperature. The experimenter's screen shows current value of the major physiological parameters of the cardiovascular, respiratory, and sensorimotor systems, critical information about the presence of various extrasystoles; drop in certain parameters below acceptable values; and a composite risk index characterizing general stress. Another "engineering" screen displays parameters related to the technical running of the experiment.

Figure 1: One-level multiprocessor system

Figure 2: Two-level multiprocessor system

Figure 3: Three-level multiprocessor system

GASTROINTESTINAL SYSTEM

(See also: Adaptation: M105; Nutrition: P475; Radiobiology: P470)

PAPERS:

P453(11/87) Medkova IL, Zhiznevskaya OV, Smirnov VI, Lebedev VI, Artamasova YeM.

Change in the concentration of bile acids and lipids in human bile during hypokinesia with head-down tilt with and without countermeasures.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 31-37; 1986.

[9 references; none in English]

Gastrointestinal System, Bile Acids and Lipids; Metabolism, Calcium
Humans, Males

Hypokinesia with Head-Down Tilt, Long-term; Countermeasures, Physical
Exercise, Drugs

Abstract: Subjects in this experiment were 15 healthy men, aged 30-40, subjected to 120 days of bed rest with head-down tilt of -4.5° . The subjects were divided into 4 groups: group 1, the control group (N=3) received no prophylactic measures; group 2 (N=4) followed a program of physical exercise; group 3 (N=4) was given a set of pharmacological preparations, including xydiphon to normalize calcium metabolism; group 4 (N=4) received both exercise and drugs. [Note: these are undoubtedly the same subjects as were studied in P451 (Cardiovascular and Respiratory Systems). Duodenal intubation was performed during the baseline period and on days 20, 67, 90, and 112 of hypokinesia, as well as on days 7 and 20 of the recovery period. Chromatography was used to determine the quantities of bile acids and bile lipids in portions B and C. Calcium concentration was also determined.

Subjects in group 1 (control) displayed an increase in tauroconjugates early in hypokinesia followed by a decrease to baseline and a drop below baseline during recovery. A similar pattern occurred with glucoconjugates. Thus, total bile acids increased and then decreased. In both duodenal portions, the ratio of cholates to cholesterol decreased during hypokinesia in this group. Beginning on day 67, the ratio of phospholipids to cholesterol increased. Concentration of lipid complexes also increased late in hypokinesia. The concentration of calcium in both portions of the bile increased in these subjects, particularly toward the end of the treatment. Group 2 subjects displayed an increase in tauroconjugates during hypokinesia, followed by a decrease during recovery. A similar pattern occurred with glucoconjugates, but differences were observed between the two portions. Total bile acids increased in group 2 during treatment, but had decreased by day 20 of recovery. The ratio of glucoconjugates to tauroconjugates in this group had dropped sharply by day 90 of the treatment and subsequently normalized by day 112 in portion C. There was a decrease in the ratio of phospholipids to cholesterol, and a tendency for lipid complexes to decrease. There were cyclical fluctuations in level of calcium in both bile portions in this group. Subjects in group 3 displayed a pattern of change in tauroconjugates (increase then decrease) similar to that shown in the first two groups. There was also a tendency for glucoconjugates and total bile acids to increase. The ratio of glucoconjugates to tauroconjugates decreased similar to subjects in group

GASTROINTESTINAL SYSTEM

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2, while the ratio of phospholipids to cholesterol tended to increase. This group displayed a decrease in the concentration of lipid complex in portion B during both hypokinesia and recovery, as well as decrease of calcium concentration (to 30% baseline) in portion B and an increase in portion C to (420%) followed by a decrease. Group 4 subjects displayed an increase of tauroconjugates in both portions during hypokinesia. On day 20 level of glucoconjugates had dropped by a factor of 2 in portion B, with no change in portion C. On day 67, this level increased in both portions. In both bile portions, group 4 subjects showed a nonsignificant tendency for total bile acids to increase toward the end of hypokinesia. The ratio of gluco- to tauroconjugates fluctuated cyclically throughout the experimental period. The cholate/cholesterol ratio increased due to an increase in cholates, while the ratio of phospholipids to cholesterol was elevated during various periods, because of a drop in cholesterol. The changes in calcium concentration in this group were similar to those in group 3, except that the elevation in calcium was less marked.

Results of this study showed that the total concentration of bile acids had dropped by the end of hypokinesia in the group 1 (hypokinesia alone) subjects, while in the other subjects it remained elevated. The level of cholesterol esters in blood serum increased sharply starting on day 72 of treatment in group 1 subjects. This, in addition to the decreased concentration of cholates in the bile suggests disruption of cholesterol transformation in the bile acids. In groups 2-4, there was no evidence of hypercholesteremia, which may be associated with optimization of the synthesis of bile acids from cholesterol. Because of the combination of low levels of bile acids and high total calcium and cholesterol in the bile, it may be hypothesized that groups 1 and 2 demonstrated the greatest potential for development of gall stones. In group 2 subjects the predominance of bile tauroconjugates over glucoconjugates indicates lateralization of the synthetic function of the liver. Subjects in group 3 and 4 showed increased synthesis of bile acids, and decreased levels of total calcium and cholesterol in the bile. These effects were more pronounced in group 4. However, these groups also displayed changes (decrease in concentration of lipid complex, possibly due to decrease in phospholipid concentration) which may be dangerous with regard to gall stone formation. These results underscore the need for further research to discover countermeasures to normalize the synthetic function of the liver under conditions of hypokinesia.

Table: Changes in concentration of bile acids in bile of humans undergoing hypokinesia with head-down tilt, with and without countermeasures

GASTROINTESTINAL SYSTEM

P455(11/87)* Goland-Ruvina LG, Pechenkina RA, Goncharova NP, Smirnov KV.
Hydrolysis, transport and utilization of carbohydrates under conditions of curtailed motor activity.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 41-47; 1986.

[9 references; 2 in English]

Gastrointestinal System, Intestine, Hydrolysis and Transport; Metabolism,
Carbohydrates; Endocrinology, Pancreas

Rats

Immobilization; Psychology, Stress

Abstract: Subjects in this experiment were white male rats in which motor activity had been curtailed by use of an immobilization cage. The rats were fed dried food and unlimited water. Provocative tests using 1.5 g per 1 kg body weight of poly-, oligo- and monosaccharides (starch, maltose, glucose) were performed as a means of studying gastric and intestinal carbohydrate hydrolysis, transport and utilization of glucose produced by hydrolysis of starch and maltose, the resorption function of the small intestine and utilization of glucose by the tissues. The glycemic curve obtained after polymer (starch) loading reflects the status of the resorptive mechanism. The level of glucose in the blood was determined fasting and 30, 60, 90, and 120 minutes after carbohydrate loading. Concurrently the experimenters measured the alpha-amylase activity in a homogenate of pancreatic tissue, and alpha-amylase, invertase, maltase, and gamma-amylase in a homogenate of the duodenal mucosa and small intestine. Concentrations of radioimmune insulin and glycogen in blood were also measured. Tests were performed on 250 animals on days 3, 7, 15, 30, 60, and 90 of immobilization and, in a number of cases, after 120 days. Results were compared with those of control animals and tested statistically.

Results are shown in detail in Figures 1-3. The authors conclude that during the early days of hypokinesia, activity of carbohydrases responsible for gastric and intestinal carbohydrate hydrolysis increases, accompanied by hyperglycemia and rapid utilization of carbohydrates. This is associated with the nonspecific responses of the organism to restricted movement. By day 30 hypokinesia depresses carbohydrate hydrolysis and transport systems, and hypoglycemia develops while glucose utilization is not disrupted. During this period, glycolytic and especially oxidative carbohydrate metabolism is decreased and sensitivity to insulin is heightened. After still longer hypokinesia, carbohydrate hydrolysis and transport systems undergo an adaptive reaction: pancreatic amylase [activity] is depressed, while the enzyme-transport system of the small intestine and resorption of glucose is heightened somewhat. At the same time, glycemic curves become attenuated, suggesting retardation of glucose utilization. This results from changes in the endocrine portion of the pancreas. The lack of balance in the systems responsible for glucose homeostasis prevents normal glucose utilization. At the same time, activation of pancreatic amylases in the blood and intestinal disaccharidases ensures that glucose is supplied to the tissues and blood glucose level remains high.

P455

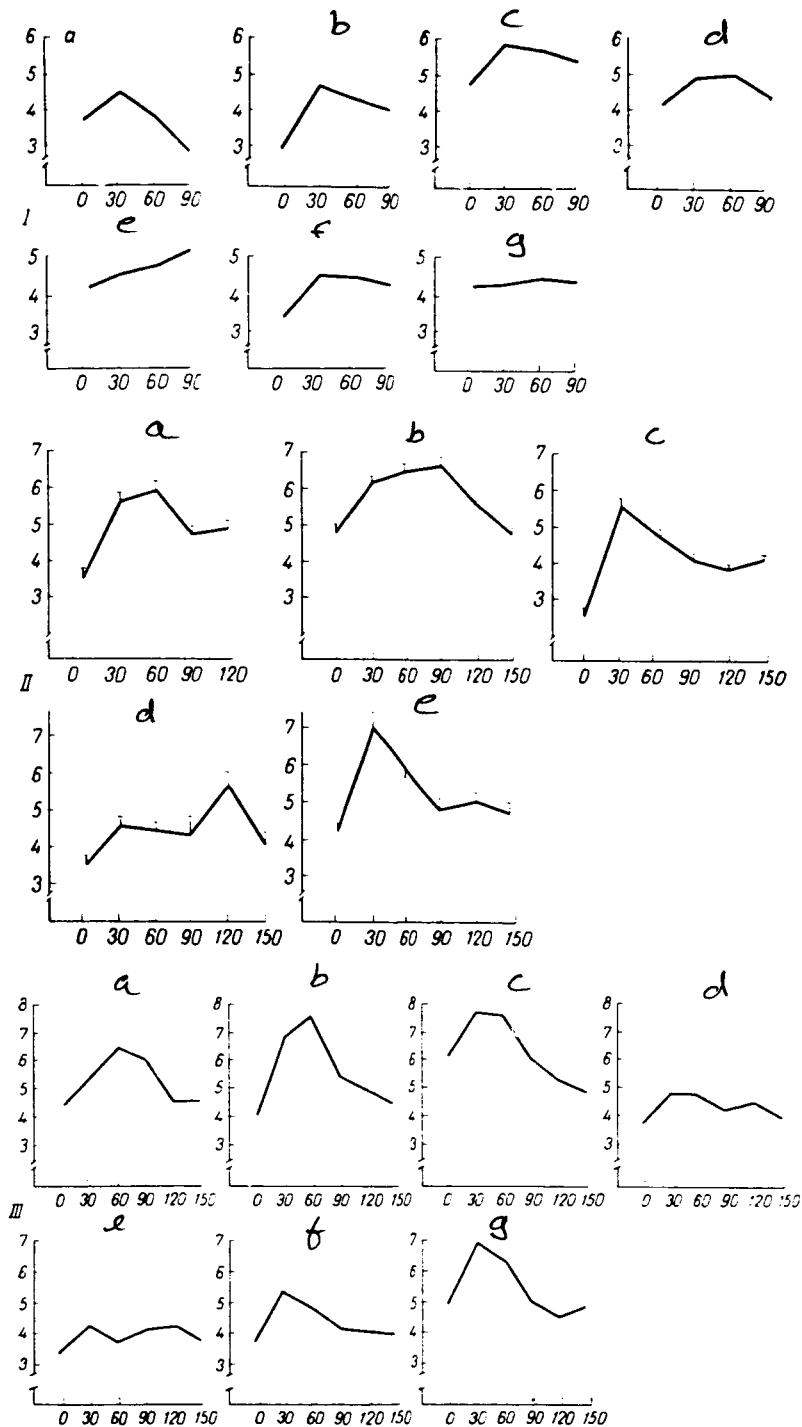


Figure 1. Glycemic curves of rats with limited motor activity. I, II, III - after starch, maltose, and glucose respectively. a - control; b - g -- on days 3, 7, 15, 30, 60 and 90 of limited motor activity, respectively. Abscissa - duration of exposure to limited motor activity (in min.) [Sic.: an obvious error, abscissa is almost certainly time in minutes after probe.]

GASTROINTESTINAL SYSTEM

P455

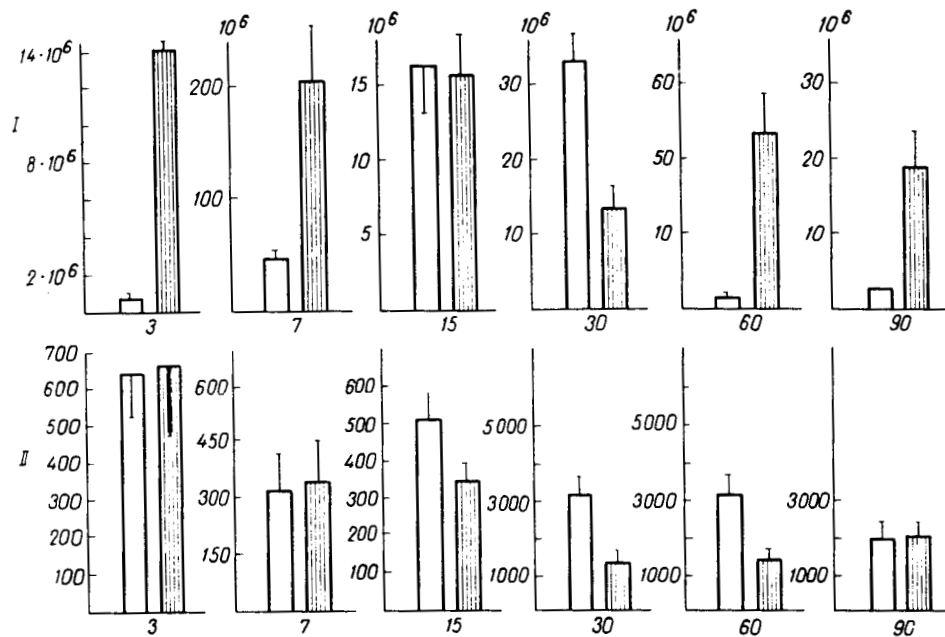


Figure 2. Pancreatic amylase activity in rats experiencing limited motor activity. I - pancreatic tissue; II - mucous membrane of the duodenum. Abscissa - duration of limited motor activity days. White bars -- control, cross-hatched -- experimental group.

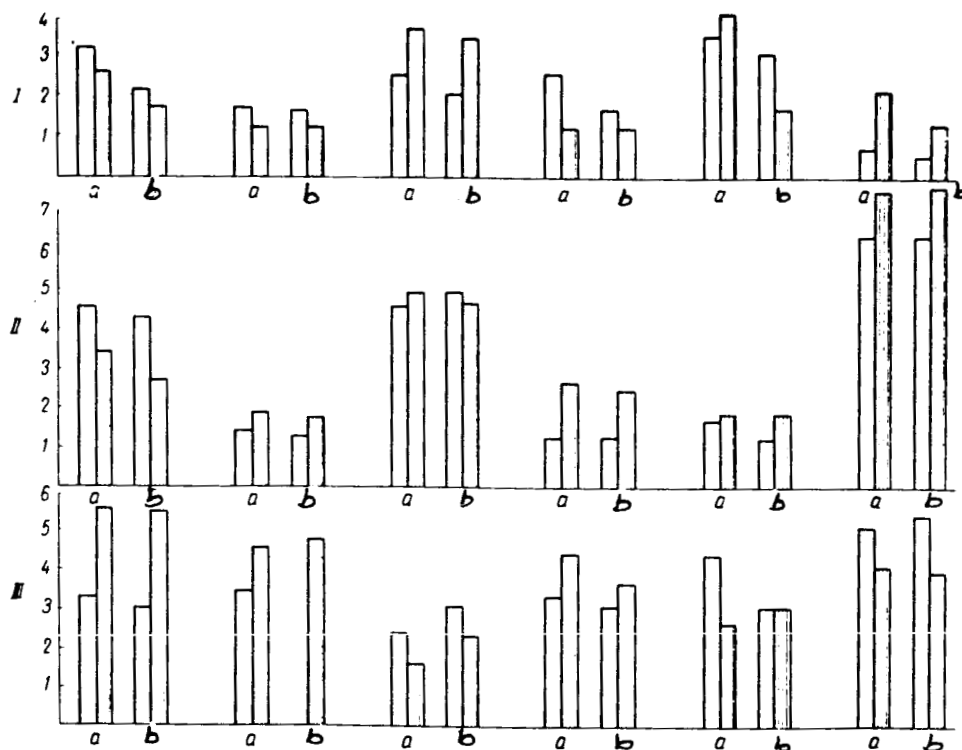


Figure 3: Carbohydrase spectrum of small intestine of rats experiencing limited motor activity. I - alpha-amylase; II - Invertase; III - maltase. a - proximal section; b - distal section. White bars - control; cross-hatched - experimental animals.

GROUP DYNAMICS

PAPER:

P466(11/87)* Terelyak Yan (Poland).

Group dynamics and performance efficiency under extreme conditions.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 82-83; 1986.

[9 references; 9 in English]

Group Dynamics, Psychology, Aggression; Human Performance, Cognitive
Efficiency and Fatigue

Humans

Adaptation, Social Adaptation, Isolation, Antarctica

Abstract: This paper summarizes the result of studies of 1-year residents of a polar Antarctic station. One such study established that aggressive behavior increases with duration of isolation. This aggression is described as adaptive in nature and therefore controllable. Physical aggression peaks during the middle of the isolation period (the winter), suggesting that this is the most difficult period with regard to adaptation to monotony. Verbal aggression peaks at the end of the isolation period, and is described as a type of compensation for extended paucity of sensory stimulation. A 1-hour test of cognitive performance involving numerical computation was administered repeatedly at 2-month intervals. While no overall decrease in cognitive performance was noted as duration of isolation increased, cognitive fatigue developed more rapidly, which the authors describe as suggesting nonspecific cognitive detriment related to sensory deprivation and monotony. A study based on the sympathy-antipathy dimension of the informal sociometric structure of the group spending a year at the polar station identified three types of social adaptation. The first, called "conservative," was applied to those who maintained a relatively good position on the approval scale throughout the period of isolation. Individuals of the "fluctuating" type showed cyclic oscillations in their approval rating; such individuals tended to be those who demonstrated independence from the group and periodically remained outside it. The "maladaptive" type showed large changes in social adaptation, most frequently associated with decrease in prestige or sympathy.

Genetics: See Botany: 504; Biospherics: BR11

HEMATOLOGY

(See also: Adaptation: P480, P497; Biospherics: BR11; Radiobiology: P477)

PAPERS:

P474(11/87)* Kalandarova MP.

The effects of space flight factors on hemopoiesis.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 7-17; 1986.

[111 references; 34 in English]

Hematology, Hemopoiesis, Hemoglobin, Erythrocytes; Musculoskeletal System,
Bone Marrow, Bone Degeneration
Review Paper, Humans, Cosmonauts, Animals
Adaptation, Space Flight Factors

Abstract: This paper presents a rather thorough review of Soviet research on effects of actual and simulated space flight factors on hemopoiesis. The author points out that in order to evaluate the limits of adaptation, one must have some information about normative values and suggests 1 ± 1.5 sigma (standard deviation) to represent the norm. Data on changes in quantities of hemoglobin and erythrocytes in space flight and hypokinesia for animals and humans are not consistent. A number of postflight examinations of cosmonauts and flight animals, have not shown decreases in the quantity of erythrocytes or dry erythrocyte weight. Data on hematocrit after space flight is important for determining whether hydremia or pachyhemia occurs in response to space flight factors. The data reviewed showed that, in general, hematocrit fluctuated within normal limits after space flight although tending to approach the lower limit of the norm. An exception to this was a 63-day Soviet flight after which cosmonauts displayed a hematocrit decreased to 34-38% of the norm during postflight observation. The author recommends the use of normal limits rather than individual or group baseline levels as a criterion against which to judge space flight-engendered changes in hematocrit. Immediately postflight, the number of reticulocytes tends to be reduced, although marked reticulocytosis may occur later. A postflight tendency to microcytosis, and spherocytosis in erythrocytes has been noted, but other studies have revealed macrocytosis. Data on changes in osmotic resistance of erythrocytes after space flight or hypokinesia are somewhat contradictory, although there are strong indications of some decrease in osmotic stability. Although some data contradict these findings, the author states that the tendency to microspherocytosis, decrease in osmotic resistance of erythrocytes (suggesting a relative increase in the proportion of old erythrocytes), and small decreases in reticulocytes and erythrocytes (compared to baseline data) may indicate some decrease in the physiological regeneration of red cells in cosmonauts during space flight. This is confirmed by the results of studies on rats showing decreased erythropoiesis. Hyporegeneration of erythropoiesis may lead to anemia and a number of Soviet studies have revealed decrease in serum iron, overall iron-binding capacity of serum, and decrease in iron concentration in hemoglobin. Generally iron deficit is accompanied by lowered resistance to infection, which has been noted in some cosmonauts. Decrease in erythropoietin in blood has been noted after long-term space flights and

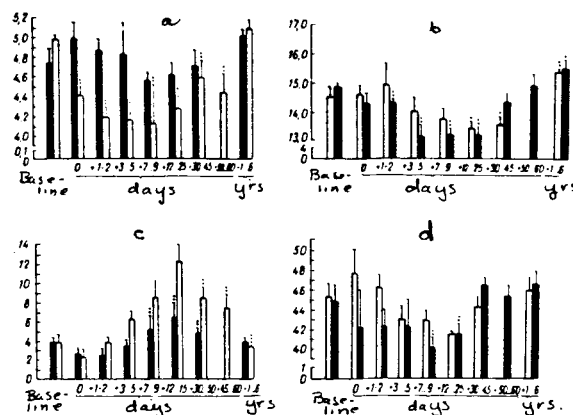
HEMATOLOGY

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hypokinesia. However, increased erythropoietin has been observed after brief flights. Inhibition of erythropoiesis during space flight in the process of physiological regeneration of bone marrow may result from lowered demands for erythrocytes under weightlessness due to a lower level of motor activity. The correlation between erythrocytes and muscle development has been well established. Because of the close connection between bone tissue and bone marrow, decreased erythropoiesis in space may also be associated with destructive processes in bone. When trying to explain decreased erythropoiesis in space, it is important to distinguish between possible explanations based on hypoplasia of bone marrow and those based on physiological decrease in hemopoiesis, since the first process is irreversible and the second reversible. The author believes that the latter process is the more likely explanation.

Table: Parameters of red blood in the norm in normal males (1) and male cosmonauts (2)

| Parameter | Group | X | X \pm 1.5 | X _{min} -X _{max} |
|------------------------------------|-------|-------|---------------|------------------------------------|
| Erythrocytes, $\cdot 10^6$ | 1 | 4.6 | 4.0-5.1 | -- |
| | 2 | 4.88 | -- | 4.72-5.15 |
| Hemoglobin, g% | 1 | 14.8 | 13.0-16.5 | -- |
| | 2 | 14.8 | -- | 13.37-18.0 |
| Color indicator | 1 | 0.93 | 0.82-1.05 | -- |
| | 2 | 0.92 | -- | 0.88-0.92 |
| Reticulocytes, % | 1 | 7.0 | 2.0-12.0 | -- |
| | 2 | 6.0 | -- | [sic.] |
| Hematocrit, % | 1 | -- | -- | 40.0-48.0 |
| | 2 | 43.0 | -- | 42.0-48.0 |
| Mean erythrocyte diameter, μ m | 1 | 7.5 | -- | 6.7-7.7 |
| | 2 | 7.5 | 7.3-7.69 | -- |
| Osmotic resistance erythrocytes | 1 | -- | 0.48-0.46 | -- |
| | | | 0.34-0.32 | |
| | 2 | 0.475 | 0.4699-0.4801 | -- |
| maximum | | | 0.338 | |
| minimum | | | 0.336 0.340 | |



P502(11/87) Agafonova NA, Lunina NV.

The effect of alpha-tocopherol acetate on the response of the lysosome system of neutrophilic leukocytes to immobilization stress.

Fiziologicheskii Zhurnal.

33(1):57-63; 1987.

[20 references; 5 in English]

Authors' affiliation: T.G. Shevchenko Pedagogic Institute, Voroshilovgrad

Hematology, Lysosomes, Neutrophilic Leukocytes

Rabbits

Psychology, Immobilization Stress, Countermeasures, Alpha-tocopherol

Abstract: Subjects in this experiment were 50 rabbits of both sexes who were immobilized on their backs for 7 hours. Half were considered controls; the other half had been given alpha-tocopherol acetate (1 mg per 1 kg body weight), an inhibitor of lipid peroxidation, for 12 days prior to treatment. Blood parameters were measured during the baseline period and 3 hours, and daily for 6 days after the treatment. Parameters investigated were: number of leukocytes and neutrophils in peripheral blood, number of myelocaryocyte (nucleus containing myelopoietic cells), partial granulocytes in bone marrow, number of neutrophil leukocytes in peripheral blood smears, and the activity of marker lysosomal enzyme to acid phosphatase. Parameters of the kallikrein bridge, indicative of the state of the clotting, fibrinolytic, kallikrein and complement systems were measured: cold activation of the kallikrein bridge between Stormorken factors XII and VII, activity and activators of plasmin in euglobulins thrombin time, recalcification time, concentration of fibrinogen, kaolin cephalin time, and complement level in 50% hemolysis.

As in the control group, animals given alpha-tocopherol acetate developed neutrophilic leukocytosis after immobilization, but it lasted a shorter time and was less pronounced than in control animals. Similarly, activation of granulocytopoiesis was less long-lasting and pronounced in treated animals. Acid phosphatase activity in experimental animals reached a maximum (3.8 times normal values) on day 1 after immobilization, while in control animals a level 6 times normal was reached on day 2. The coagulation system was activated after immobilization in both groups of animals, but to a less pronounced extent in those given alpha-tocopherol. Experimental animals showed less inhibition of fibrinolysis than controls. Prothrombin time decreased after immobilization in both groups, but in subjects receiving the antioxidant this effect was less marked and recovery faster. Complement activity increased more in control animals. Finally, 46% of the control animals died by days 3-5 after the experiment, while only 15% of the experimental group died.

The authors summarize their findings by stating that immobilization leads to pronounced neutrophilic leukocytosis and circulation of lysosomal enzymes of neutrophilic leukocytes. In addition, an imbalance in the functioning of the systems dependent on the Hageman factor occurs. In particular, while there is strong activation of hemocoagulation, kininogenesis and complement systems, fibrinolysis is inhibited. Under these conditions the most important regulatory systems become pathogenetic factors, as indicated by the death of the subjects. When alpha-tocopherol acetate is introduced, stabilizing the membrane structure

HEMATOLOGY

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of lysosomes of all tissues, extent and duration of neutrophilic leukocytosis and influx of lysosome enzymes of neutrophils in circulating blood are moderated. Thus, the effects on the coagulation, kininogenesis, complement, and fibrinolysis systems are less pronounced and death rate decreases by a factor of 2.

Table 1: Effects of alpha-tocopherol acetate on concentration of neutrophils in peripheral blood and bone marrow tissue, and on the number of lysosomes with neutrophilic leukocytes after immobilization stress

Table 2: Effects of alpha-tocopherol acetate on activity of acid phosphatase and certain parameters of the hemostasis system after immobilization stress

Table 3: Effects of alpha-tocopherol acetate on the "kallikrein bridge" and complement activity after immobilization stress

HUMAN PERFORMANCE

(See also: Adaptation: P480, P497; Aviation Physiology: P496; Equipment and Instrumentation: P494; Group Dynamics: P466; Neurophysiology: P449; Operational Medicine: CR5; Perception: P500; Psychology: P499, M107)

PAPERS:

P476(11/87)* Ioseliani KK, Ryzhov BN.

Relationship between information processing and effort and operator cognitive performance [Literally: Information-activation ratio and psychological work capacity of operators]

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 17-21; 1987.

[12 references; none in English]

Human Performance, Information Processing, Cognitive Performance,
Efficiency

Humans, Pilots, Patients

Psychology, Motivation, Effort

Abstract: This study utilized three groups of pilots. The first group contained 15 men who had been referred for examination because of moderate functional disorders (aftermath of mild concussion, neurocirculatory distonia, autonomic vascular instability, etc.). Group 2 contained 12 operators with more severe medical disorders (stage I hypertension, gastritis, early ischemic heart disease, etc.). Group 3 consisted of 18 apparently healthy pilots. Observations and history indicated that all members of group 3 and the majority of group 1 were highly motivated to succeed at the experimental task, believing it would enhance their flight certification chances. Members of group 2 were less motivated with respect to this task. The task involved a display panel with 10 light displays which were matched with 10 buttons. The operator was instructed to push the appropriate button when a light flashed. Lights were flashed according to a random pattern at 5 different rates, ranging from 1 per second to 1 per 0.4 second. An operator worked at each rate for a total of 2 minutes. Information-processing capacity for each rate was determined for each operator. Psychological cost (or effort) of performance was determined on the basis of heart rate, respiration rate, minute respiratory volume, and temperature of the palm of the left hand. Efficiency of performance (E) was considered to equal: $E = I \cdot (1 - G)$, where I is information processing capacity in bits per second, and G is an index of stress based on physiological indicators and varying between 0 and 1. Relationship between physiologically manifested effort (stress) and information presentation rate was positive and approximately linear for all presentation rates for groups 1 and 3. In group 2, effort increased linearly with rate only up to the point of 6 bits/second; after this point, further increases in rate led to decreases in effort. Information-processing performance degraded more rapidly with increases in rate for subjects in group 2 than in group 3, with group 1 occupying an intermediate position. Motivated operators showed signs of increased effort (changes in position, perspiration) as rate increased, while operators in the less motivated group did not. At a moderate presentation rate of 5-6 bits/second there were only negligible differences in the efficiencies of the three groups. At high rates, highly motivated groups were more efficient, while less motivated subjects were more efficient at low rates, where all groups performed with virtually

HUMAN PERFORMANCE

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100% accuracy. The authors conclude that these results suggest that measures of productivity are insufficient for diagnosing work capacity. They further conclude that rates of presentation of 5-6 bit/second are best for testing individual work capacity for sensorimotor tasks.

Figure 1: Psychophysical cost for operators working at various rates.

Figure 2: Information-processing capacity at various work rates.

Figure 3: Efficiency of performance at various work rates.

P491(11/87)* Denisov AF.

Psychological state in air traffic controllers during job performance,
Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
21(1):76-78.

[12 references; none in English]

Psychology, Psychological State
Humans, Air Traffic Controllers
Human Performance, Workload, Performance Quality

Abstract: Subjects in this multiyear study were a total of 70 air traffic controllers (aged below 35, mean time in job 7 years), subdivided into 2 groups on the basis of expert evaluation of their overall job performance (group 1 = successful, group 2 = less successful). A number of parameters indicative of psychological state were measured before and after a work shift during periods of relatively light or heavy air traffic. Parameters measured were: indices of anxiety and activity derived from the Luscher Color Test (activity is a measure of preference for "active" colors); measured static tremor, a coefficient of impulsivity (ratio of errors to time to traverse a maze with a tremograph); amount of perspiration, overall performance on a tapping test; and index of endurance derived from tapping test (ratio of number of taps in last 10 seconds to taps in first 10 seconds).

When before- and after-shift parameter values for a period of heavy traffic in 1981 were compared, it was found that both groups showed tension before the shift; afterward, less successful workers showed significant increases in anxiety and impulsivity, while successful workers showed increases in tremor. In another heavy period in 1983, before the shift better workers had lower anxiety coefficients than less successful ones, and after the shift this difference was further enhanced with anxiety dropping from preshift values in group 1, and increasing in group 2. Group 1 had a higher impulsivity score before the shift than group 2, but after the shift this score decreased for the former and increased for the latter. Endurance score remained the same for group 1, but decreased after the shift for group 2. Scores and changes in scores after shift performance were also compared in the two groups for light and heavy air traffic conditions. For less competent, group 2, workers, heavier job demands led to greater changes in psychological parameters than for group 1 workers; group 2 showed greater increases in anxiety, and less pronounced decreases in activity. Group 2 workers also showed greater increases in hand tremor after a heavy shift. Analogous differences occurred after lighter work shifts. The author interprets these results as suggesting poorer adaptation in group 2 subjects to both workloads. Subgroups of controllers with gastrointestinal disorders tended to show greater changes in psychological parameters after a work shift than healthy counterparts. Controllers with cardiovascular problems showed greater increases in perspiration and hand tremors after a shift than healthy ones.

Table 1: Changes in parameters indicative of psychological state in different groups of air traffic controllers

Table 2: Changes in psychological parameters with varying work loads

HUMAN PERFORMANCE

P498(11/87) Kolpakov SP, Rumyantseva AG.

Comprehensive method for correcting psychophysical state in people whose work involves constant eye strain.

Fiziologiya Cheloveka.

13(1):42-49; 1987.

[23 references; 3 in English]

Authors' affiliation: P.K. Anokhin Scientific Research Institute for Normal Physiology, Moscow

Human Performance, Psychophysiological State

Humans, Industrial Workers

Perception, Visual System, Eye Strain; Countermeasure, Exercises, Massage

Abstract: Subjects in this experiment were 20 workers in the vacuum tube industry, aged 18-34, in their present jobs from 6 months to 10 years. Nine subjects worked in the manufacture of vacuum tubes, and 11 were monitors of electronic optical systems. Workers were tested using a set of physiological, psychological, and psychophysiological tests. Functioning of the accommodation mechanism of the eye was assessed by measuring amplitude of accommodation no less than 3 times for each eye. A paper and pencil test was used to determine rate, accuracy, and productivity of information processing. Systolic, diastolic, pulse pressure and heart rate were also measured. Subjects were asked to rate their own levels of anxiety and fatigue. Job productivity was also assessed. For either 5 or 10 days, between 10:00 and 12:00 a.m. workers participated in a corrective conditioning program. The 5-day program involved gymnastics, self-massage and exercise of the accommodating apparatus of the eyes, and selective self-massage, including stimulation of biologically active points. The 10-day course was apparently identical, except that subjects were massaged by professional masseurs for 10-15 minutes. It is implied but not stated that those working on the electronic optical system underwent the 10-day program, while the tube assemblers underwent the 5-day one. All parameters were measured before and after each session during the program. Before the beginning of the experiment, and immediately and 1-1.5 months after the program, subjects' on-the-job productivity was evaluated. Parameter values of the same workers measured 3-5 days before the beginning of the experiment were used as baseline values.

It was found that the baseline level of amplitude of accommodation was half of the norm for these workers. All subjects complained of fatigue after their shift, pain in the eyes and neck, and frequent headaches. Scores on the information processing test, indicative of concentration and perception, were generally higher than the norm. After the 10-day program, amplitude of accommodation in both eyes had improved significantly (increased by 60% and 84.6%, for right and left eye), but this parameter had returned almost to baseline after 1-1.5 months. In addition after these subjects completed their program, heart rate decreased and pulse pressure increased, and diastolic blood pressure tended to decrease. Rated anxiety decreased, work productivity increased, as did speed and amount of information processed in a short interval. After 1.5 months information processing scores decreased somewhat. After the 5-day program amplitude of accommodation increased by 62.0% for the right eye and 72.8% for the left eye. Immediately after completion of the program, systolic blood pressure and heart rate decreased for these subjects, and there was a tendency for diastolic blood pressure to do the same. Work productivity increased by

P499

15% but this was not statistically significant. Speed and accuracy of information processing decreased, and no changes were noted in self-rated anxiety or fatigue. After 1-1.5 months, values of amplitude of accommodation and information processing parameters dropped below baseline for this group. The authors recommend this methodology which is relatively easy to implement for workers in jobs conducive to significant eye strain. Nothing is said about how often this program should be given nor how much time should be devoted to it.

Table 1: Changes in parameters in 11 workers indicative of functional state after participation in a 10-day program of corrective measures

Table 2: Changes in parameters in 9 workers indicative of functional state after participation in a 5-day program of corrective measures

IMMUNOLOGY: See: Operational Medicine: CR5

LIFE SUPPORT SYSTEMS

(See also: Endocrinology: P477; Microbiology: P106;
Operational Medicine: P470)

PAPERS:

P463(11/87)* Grishayenkov BG, Vasil'yev VK, Zorina NG, Zhukov AK.

Derivation of working equations for a gas mixture of $\text{CO}_2\text{-CO-H}_2\text{O-H}_2\text{-N}_2$ for cathode space of an electrolyzer with a solid electrolyte with oxygen extraction accounted for.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 73-76; 1986.

[1 reference; none in English]

P464(11/87)* Grishayenkov BG, Zorina NG, Vasil'yev VK.

Computation of equilibrium concentrations of components of the gas mixture $\text{CO}_2\text{-CO-H}_2\text{O-H}_2\text{-N}_2$ for the cathode space of an electrolyzer with a solid electrolyte and appropriate theoretical values for voltage of dissociation.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 76-79; 1986.

[no references]

P484(11/87)* Grishayenkov BG, Zorina NG.

Thermodynamic state of a multicomponent gas mixture $\text{CO}_2=\text{CO}=\text{H}_2\text{O}=\text{H}_2=\text{N}_2$ in an electrolyzer with a solid electrolyte.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 55-58; 1987.

[no references]

Life Support System, Gas Mixture Regeneration System

Equation Derivation

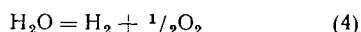
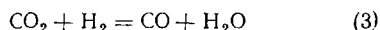
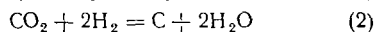
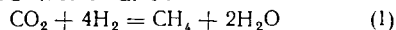
Thermodynamics, Equilibrium

Abstract: These three papers derive information about a multicomponent gas mixture containing $\text{CO}_2\text{-CO-H}_2\text{O-H}_2\text{-N}_2$ in the cathode space of an electrolyzer with a solid electrolyte for use in designing the gas mixture regeneration component of a life support system. The first paper derives the equations describing the thermodynamic equilibrium of the mixture. These equations account for the fact that the oxygen initially present in the molecule escapes from the reaction chamber to the oxygen (anode) chamber. Expressions for equilibrium partial gas pressures, thermal effect of reactions, theoretical voltage of dissociation, and others were derived as a function of temperature, total pressure of the gas mixture, initial gas composition, and coefficient characterizing amount of oxygen transfer from the cathode to the anode cell of the electrolyzer.

The second paper computes the equilibrium concentrations for the gas mixture in the electrolyzer cathode space, using the equations obtained in the previous paper. It was found that the curves describing the theoretical decomposition voltage of the gas mixture as a function of oxygen concentration are S-shaped for all temperatures studied. When the temperature of the electrolyzer increases, the curves are displaced so as to lower the theoretical value of tension.

P463, 464, 484

The third paper investigates the thermodynamic state of the mixture $\text{CO}_2=\text{CO}=\text{H}_2\text{O}=\text{H}_2=\text{N}_2$ in the cathode space of the electrolyzer. This makes it possible to determine theoretical voltage of decomposition at the outlet of the electrolyzer or an individual cell, which is important for designing the regeneration system. To describe thermodynamic equilibrium of this gas mixture, equations of 4 independent reactions must be considered, since the difference between the number of substances and the number of atoms is 4. The reactions selected here are:



The system of equations derived can be simplified considerably if carbon formation, or methane formation does not occur and if $N_{\text{CH}_4}^0 =$, or if carbon and methane formation occur simultaneously.

Tables and Figures from P464.

Table: List of parameters characterizing the gas mixtures described

Figure 1: Graph of theoretical voltage of decomposition an partial pressure of gas mixture components as a function of loss of oxygen for a gas mixture with given concentrations of components

Figure 2: Nomogram for determining theoretical voltage of decomposition of the gas mixture with various partial pressure of oxygen and concentration of oxygen for electrolyzer temperature of 1000°K.

MATHEMATICAL MODELING

(See also: Cardiovascular and Respiratory Systems: P467; Neurophysiology: P489; Operational Medicine: CR5)

PAPER:

P460(11/87)* Kondrachuk AV, Shchekin IYe, Sirenko SP.

A mathematical model of the otolith.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 66-70; 1986.

[15 references; 6 in English]

Mathematical Modeling

Mammals

Neurophysiology, Otolith

Abstract: It is generally believed that changes in otolith function are associated with space motion sickness. It is also believed that otolith receptors are stimulated when the membrane, acted upon by forces such as gravity, moves parallel to the macula and bends the hairs of the receptor cells. Current models of the otolith treat the otolith membrane as an absolute solid moving in the plane of the macula. However, experiments have shown that in mammals the otolith membrane deforms with degrees of freedom associated with the deformation. This means that the motion of the otolith membrane does not reduce to that of a mass point, but is more like that of an elastic sheet (membrane) fixed at the edges, or a flexible shell, or even a drop of viscous liquid. In other words, the otolith membrane is a system with distributed parameters. One might hypothesize that the resonance effects in the degrees of freedom caused by deformation are responsible for disruption of otolith functioning on moving vehicles. The present model treats the otolith membrane as a circular heavy elastic membrane resting on a flexible base formed by a system of supporting bars.

To evaluate the behavior of this model, the authors analyzed free transverse oscillations of such a membrane. Parameters modeled included deflection functions, cylindrical rigidity, membrane thickness, Poisson coefficient, specific elasticity coefficient of the base, and weight of a unit area of the membrane. Two conditions are examined with regard to the way the membrane is attached to the base. In the first, the supports are considered as an evenly distributed set of inelastic rods which temporarily develop a force when the edge of the membrane bends. In the second condition, the membrane is considered to be connected to the base with an elastic connection. Since the otolith membrane is immersed in the endolymph, when transverse oscillations are computed, one must consider the movement of the liquid leading to decreased oscillation frequency. The lower frequency of transverse oscillation can be calculated given values for density of the otolith and endolymph. Calculations showed that the otolith membrane parameters are consistent with the possibility of the otolith membrane undergoing its own low frequency transverse oscillations, and thus an external force (e.g., the motion of the sea) containing low frequency components might generate resonance effects. Since otolith receptors respond to displacement of the membrane parallel to the macula, membrane movement accompanied by deformations, particularly transverse oscillations, which bend the hair cells back and forth, would lead to unusual stimulation of the otolith receptors.

MATHEMATICAL MODELING

Figure 1: Diagram of otolith structure

Figure 2: Qualitative behavior of the otolith membrane as a system with distributed parameters

Figure 3: Possibility of the otolith membrane twisting if the center of rotation does not coincide with the center of gravity under exposure to linear acceleration

METABOLISM: See Adaptation: M105; Body Fluids: P450; Endocrinology: P477; Gastrointestinal System: P453; P455; Nutrition: P475)

MICROBIOLOGY

(See also: Nutrition: P475; Radiobiology: P462; P470)

MONOGRAPH:

P106(11/87) Sytnik KM (editor).

Kosmicheskaya Biologiya i Biotekhnologiya: Sb. Nauch. Tr.

[**Space Biology and Biotechnology: A Collection of Scientific Works**].

Kiev: Naukova dumka; 1986.

[72 pages; 29 figures; 10 tables; 130 references for all articles]

Affiliation (book): Institute of Molecular Biology and Genetics, Ukrainian Academy of Sciences.

KEY WORDS: Microbiology, Space Biology, Biotechnology, Botany, Bacteria, Algae, Pea, Haplopappus, Orchids, Chlorella, Space Flight, "Salyut-7", Weightlessness, Bioconvectivity, Cytology, Clinostatting, Biological Rhythms, Vibration, Acceleration, Life Support Systems, Electrophoresis

Annotation: This collection contains papers covering many aspects of space research: study of the effects of space flight factors on plants and microorganisms and analysis of the possible reasons for these effects; and the theoretical underpinnings of planned experiments in space biotechnology, particularly electrophoresis of biopolymers. This collection is intended for scientists, engineers, technicians, and advanced students in relevant areas.

NOTE: In lieu of a table of contents we are presenting translations of short abstracts of the papers in this collection.

Man'ko VG, Kordyum VA, Vorob'yeva LV, Kon'shin NI, Nechitaylo GS. **Changes in Proteus vulgaris cultures grown in ROST-4M2 devices on "Salyut-7."** Pages 3-9.

This paper cites results of an experiment with Proteus vulgaris bacteria in the new ROST-4M2 cultivation device, which allows samples to be taken from a sequence of compartments during space flight. Analysis of these samples showed that the course of adaptation to cultivation conditions in the ROST-4M2 on Earth and during space flight are different, as expressed in differences in growth rate, morphological characteristics, and bacterial mobility on solid agar.

Babskiy VG. **On the role of processes of mass transfer in cultivation of microorganisms in weightlessness.** Pages 10-18.

This paper analyzes a hypothesis concerning the possible effects of bioconvection on the results of experiments on cultivation of microorganisms under weightlessness, in particular the reasons for the occurrence of spatially nonhomogeneous distribution of microorganisms evoked by chemotaxis. It is demonstrated that the facts known about the effects of space flight factors on microorganisms cannot be explained by the occurrence of bioconvection.

M106

Popova AF. **Submicroscopic organization of Anabaena azollae Strasb. cells during space flight.** Pages 18-22.

This paper cites results of research using electron microscopy on cells of symbiotic blue-green (glaucous) algae Anabaena azollae Strasb. found in the air spaces of chlorophylliferous leaf segments of the water fern Azolla pinnata. Experimental plants were grown in the IFS-2 device on board the "Salyut-6" for 7 days (joint Soviet-Vietnamese experiment). The ultrastructure of algae in the ground and flight condition is shown. A number of restructurings of submicroscopic organization were found in the flight plants. Based on the data obtained, the author concludes that space flight conditions have no significant inhibitory effects on the ultrastructure of cells of the Anabaena azollae blue-green algae.

Zaslavskiy VA, Fomichev VM. **The functional state of chromatin in proliferation activity of cells in the meristem of pea sprouts clinostatted at different rates.** Pages 23-28.

Cytophotometry and autoradiography were used to study the state of chromatin and proliferation activity in the cells of the root meristem of pea sprouts clinostatted at different rates (2 and 50 rev/min). It is demonstrated that only "fast" clinostatting has a significant effect on the parameters measured: there is a redistribution of diffuse and condensed chromatin, and a decrease in the size of the proliferation pool. It is hypothesized that the responses of the cells to these effects involve the highest level of metabolic regulation -- the genetic.

Viktorova NV, Sidorenko PG, Fomicheva VM. **The rhythm of reproduction in plant cells in vitro and in vivo under microgravity.** Pages 28-32.

Light optic microautoradiography was used to detect changes in the diurnal course of mitotic activity of a population of Haplopappus cells in a suspension culture, and also changes in the proliferation activity of cells of the meristem exposed to clinostatting at different rates. Possible reasons for changes in the rhythm of diurnal variations in mitotic activity of plant cells are discussed in relation to existing mechanisms for endogenous regulation of cellular pressure.

Popova AF, Sidorenko PG, Klimchuk DA, Zhad'ko SI, Martyn GM, Ivanenko GF. **An investigation of the structural and functional characteristics of one-celled algae and cell cultures of higher plants exposed to simulation of individual space flight factors.** Pages 33-44.

This paper presents the results of experiments studying the effects of vibration and acceleration, during simulated launch of a spacecraft into orbit, and also of clinostatting at rates of 2 and 50 rev/min on the growth and structural and functional properties of cells of Chlorella vulgaris (line LARG-1) and Haplopappus gracilis. After a short exposure to vibration and acceleration some changes were observed in the submicroscopic organization of a number of organelles, particularly the nucleus, mitochondria, and endoplasmic reticulum, which recovered relatively quickly after vibration and acceleration stopped. Chemoluminescent analysis was used to demonstrate the sharp increase in the intensity of luminescence of

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the experimental cells in the initial hours of clinostatting; subsequently luminescence stabilized and returned to control level by 24 hours after exposure. Amplitude of chemoluminescence depended on the rate of clinostatting, and the nutrition and growth paths of the cultures. During long-term clinostatting there was some restructuring of the ultrastructure of certain organelles. On the whole, the data cited testifies to the substantial capacity to adapt to the major space flight factors in one-celled plants.

Cherevchenko TM, Mayko TK, Bogatyr' VB, Kosakovskaya IV. **Future prospects for using tropical orchids for space research.** Page 41-54.

This paper describes a study of the effects of long-term space flight on the growth and development of tropical orchids: Epidendrum radicans, Doritis pulcherrima, Dendrobium kingianum, Paphiopedilum hybrida, Paphiopedilum insigne, Anoectochilus dawsonianus. It was discovered that epiphyte orchids, because of their attenuated geotropic response and a number of other biological characteristics, are less sensitive to actual space flight factors than the terrestrial orchids. They could serve as model subjects for the study of the properties of growth and form changes during long-term space flights, and could also be used on board space stations.

Zhukov MYu, Korol' LYe, **Convective, diffusive, and electromigrational widening of zones in free-zonal fluid electrophoresis.** Pages 54-66.

This paper presents the results of a comparison of the theoretical and experimental analysis of the behavior of zones of a sample in free-zonal liquid electrophoresis. Various reasons for the widening of the zone are analyzed, and particular attention is paid to the role of the stabilizing density gradient of sucrose in transforming the convective disassembly of the zone. Theoretical and experimental data showed satisfactory agreement, testifying to the appropriateness of the mathematical model constructed for use in experiments on electrophoresis in weightlessness.

MUSCULOSKELETAL SYSTEM

(See also: Adaptation: M105; Body Fluids: P450; Hematology: P474;
Nutrition: P503)

PAPERS:

P452(11/7) Khristova LG, Gidikov AA, Aslanova IF, Kirenskaya AV, Kozlova VG, Kozlovskaya IB. (Bulgaria, USSR)

The effect of immersion hypokinesia on human muscle potential parameters.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 27-31; 1986.

[10 references; 6 in English]

Musculoskeletal System, Muscle, EMG, Potential
Humans
Hypokinesia, Immersion

Abstract: Six individuals were subjected to 3 days of "dry" immersion in a horizontal position. Parameters indicative of stimulated and averaged EMG potentials of the biceps brachii muscles were measured before and after this treatment and in the case of one individual also on day 2 during treatment. To obtain stimulated potential the cutaneous nerve was stimulated between the heads of biceps brachii muscles with a series of 4 rectangular electrical impulses with duration of 1 msec. and frequency of 1 imp/sec. The intensity was selected to induce pronounced contractions in the muscle. Potentials were recorded with the aid of a multi-electrode fixed above the distal portion of the head of the biceps brachii not less than 20 mm away from the motor zone of the ends of the muscle fibers. Impulses were amplified and recorded on tape. The four stimulated potentials from the same electrode were averaged. The rate of propagation of the stimulated potentials (V_{st}) was estimated on the basis of the length of the interval between the negative maxima of potentials registered by the 2 monopolar and the 2 branched electrodes which were a constant distance apart. Averaged potentials of the total EMG were recorded while the subject exerted isometric tension 50% of maximum. Either 64 or 128 segments of the total EMG were averaged for each value.

After 3 days of immersion, the speed of propagation of stimulated muscle potential had decreased significantly in all subjects (by an average of 28%). Rate of propagation of averaged potential decreased by 31%. Duration of the negative phase of stimulated and averaged potentials did not change as a result of immersion, while the spatial extent of the negative phases decreased significantly. Duration of the final positive phase of both types of potentials increased after immersion by approximately a factor of 2. Study of the vectroelectromyographic images of the potentials indicated that their spatial properties had also changed, with angles becoming more acute. These changes cannot be attributed to lowered body temperature due to immersion, since the water was at a temperature of 33°C. The authors state that the reasons for the observed changes are not clear.

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Table: Mean values of duration and computed length (extent) of the negative phase of stimulated and averaged EMG potentials before and after a 3-day period of immersion

Figure 1. Diagram of the multi-electrode

Figure 2: Stimulated and averaged potentials of total EMG in biceps brachii muscles before and after a 3-day period of immersion

Figure 3: Vectorelectromyographic images of stimulated and averaged potentials of total EMG

MUSCULOSKELETAL SYSTEM

P454(11/87)* Durnova GN, Sakharova ZF, Kaplanskiy AS, Ivanov VM, Khaydakov MS.

Quantitative analysis of osteoblasts and osteoclasts in the bones of rats undergoing simulations of weightlessness.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 37-41; 1986.

[15 references; 4 in English]

Musculoskeletal System, Osteoblasts, Osteoclasts

Rats, Males

Immobilization; Psychology, Stress; Tail-suspension

Abstract: Experiments were performed on a total of 60 male Wistar rats. Experimental animals were confined in immobilization cages for 35 or 60 days or placed in a tail suspension device for an unspecified period. Control rats were maintained under normal laboratory conditions. After treatment termination, animals were weighed and then sacrificed. The tibia and lumbar vertebra were isolated and the muscles removed. The length of the tibia was measured and the bones fixed with formaldehyde. The bones were decalcified, dehydrated; cross-sections 5-7 μm thick were prepared by cutting parallel to the long axis at 25-50 μm intervals and stained. The number of osteoblasts and osteoclasts were counted in 15-20 microscopic fields directly above the epiphyseal cartilage growth layer. Only functionally active cells, i.e., those polygonal and fusiform in shape, with extensive pyroninophilic cytoplasm and eccentric nuclei, were counted as osteoblasts. Osteoclasts were considered to include not only giant multinucleated cells, but also those with one or two nuclei and light pink foamy cytoplasm. In addition, relative density of primary and secondary spongiosa, the width of the epiphyseal cartilage growth layer, and width of the primary spongiosa zone were measured. All data was expressed in terms of percent of vivarous control.

Measurements of controls showed that in the norm the width of the growth layer, and relative density of the primary and secondary spongiosa are greater in the vertebra than in the tibia, while the number of osteoblasts in primary spongiosa is greater in the tibia, and the number of osteoclasts in the two bones are equal. Both hypokinesia durations as well as tail suspension led to the development of osteoporosis, as indicated by decreased relative density of primary and secondary spongiosa. This effect increased as hypokinesia increased in duration. Experimental animals also showed decrease in length of the tibia and narrowing of the growth layer and primary spongiosa zone in both the tibia and the vertebra. Both treatments led to a statistically significant decrease in number of osteoblasts in the primary spongiosa zone in both bones. Osteoblasts in the experimental animals were likely to show diminished functional activity (i.e., be fusiform with only moderately pyroninophilic cytoplasm). In experimental animals, osteoblasts tended to occur in small groups in the spaces between the trabeculae, while in control animals these cells were arranged in rows on the surface of the trabecula. No statistically significant differences were found in osteoclasts in the tibia of any experimental group, although there was a significant decrease in the lumbar vertebrae of animals undergoing 60 days of immobilization. No morphological effects were seen in osteoclasts. The authors conclude that osteoporosis in the spongiosa of the tibia and vertebra of animals in both models of weightlessness is primarily caused by inhibition of

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growth and new growth of bone. It is not clear from these results whether changes in resorption are present. Increase in osteoclasts found in other experiments with shorter term (14 day) tail suspension is attributed to early stress reactions. It is also concluded that osteoporosis is more extreme in immobilized animals than in tail-suspended ones, due to the greater stress of immobilization, as further evidenced by decrease in body, thymus, and spleen weights.

Table: Results of histomorphometric analyses of tibia and lumbar vertebrae in rats exposed to clinostatic hypokinesia [immobilization] and tail suspension (in % of controls)

| Parameter | Hypokinesia | | | Suspension | |
|---------------------------------|------------------|----------------------------------|------|------------|-----------------|
| | 35 days tibia | 60 days tibia lumbar vertebra | | tibia | lumbar vertebra |
| Bone length | -- | -4 | -- | -3 | -- |
| Width of growth layer | -25* | -17 | -14* | -8 | -12* |
| Width of primary spongiosa zone | -51* | -42* | -69* | -34* | -22 |
| Spongiosa density | | | | | |
| primary | -21* | -53* | -38* | -8* | -14* |
| secondary | -55* | -56* | -22* | -40* | -30* |
| Osteoblasts | -42* | -49* | -36* | -22* | -35* |
| Osteoclasts | +22** | +21 | -36* | +18 | +12 |

*statistically significant differences between control and experimental groups;

** Editor's note: lack of noted statistical significance for positive differences suggests authors used a one-tailed test.

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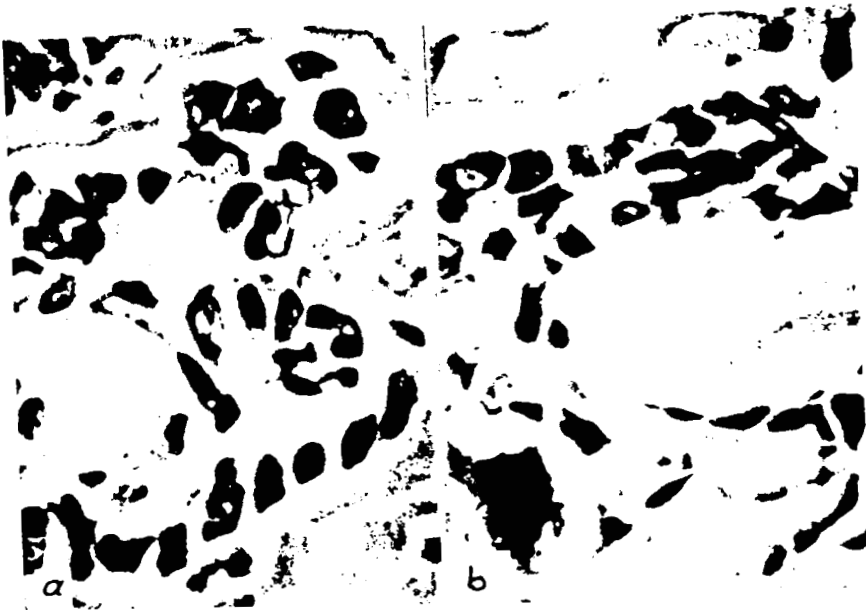


Figure 1: Osteoblasts and primary spongiosa in the tibia of rats.
a - active osteoblasts with abundant cytoplasm lining the surface of the periosteum under normal conditions;
b - decreased number of osteoblasts with predominance of less active fusiform cells after 60 days of horizontal hypokinesia.

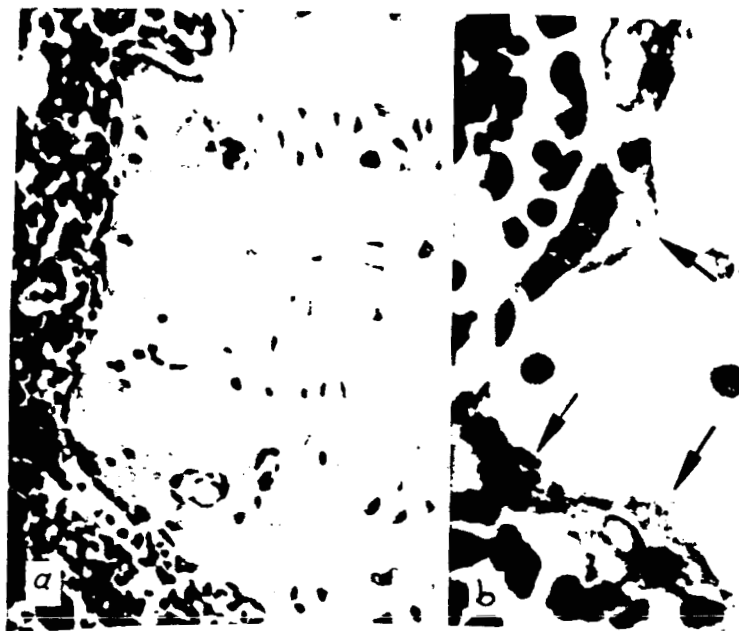


Figure 2: Active resorption of primary spongiosa in the tibia of rats after 60-days of horizontal hypokinesia
a - appearance of truncated trabecula in the primary spongiosa zone;
b - osteoclasts on the surface of truncated trabecula resorbing bone tissue

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P456(11/87)* Rogacheva IV, Polyakov AN, Volozhin AI, Stupakov GP.

[The possibility for using] Pharmacological measures to counteract regional osteoporosis in nonsupporting limbs.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 47-51; 1986.

[8 references; none in English]

Musculoskeletal System, Osteoporosis

Rats

Amputation; Countermeasures, Calcitonin, Retabolil

Abstract: This study was performed on 150 Wistar rats weighing 180-200 g. All rats had the lower third of the hind leg amputated. After amputation the subjects were divided into 4 groups. Group 1, control, animals received no drugs; group 2 animals were given 2 units MRC of calcitriol (calcitonin) subcutaneously each day; group 3 was given retabolil (0.2 ml) intramuscularly every two days; and group 4 animals received both preparations in the same doses. Treatments were continued for 20 or 40 days, after which the animals were sacrificed and the femurs isolated, fixed and refrigerated. The weight and size of the entire bone, its head, and distal portions were measured, along with their density, ash content, and mineral saturation. X-rays were used to determine the thickness of the cortical layer and width of the bone marrow cavity in frontal and lateral projection. Histological preparations of cross-sections of the diaphysis were made and stained from femur fragments of 3 animals in each group and micro-X-rays used to determine mineral saturation. Slides were prepared of diaphysis cross-sections throughout the cortical layer for both the supporting and nonsupporting femurs in a total of 62 animals and micro-X-rays taken. Each pair of micro-X-rays for a single animal was evaluated for the average level of mineralization of the microstructure under experimental and control conditions. The nonsupporting and supporting femurs of animals in group 1 were considered appropriate controls for evaluating the effects of drugs used in animals of groups 2, 3, and 4.

After 20 and 40 days, animals in group 1 showed decreased thickness in the cortical layer of the femur diaphysis in nonsupporting limbs. This effect was more pronounced in frontal than in lateral projection and there was no discernible effect on the bone marrow canal. The nonsupporting limb was lighter because of weight loss in the distal epiphysis, head, and diaphyseal portion. The density of the spongy structure of all measured portions of the nonsupporting femur was significantly lower than that of the supporting limb after 20 days. Decreased mineral saturation reflected development of osteoporosis. The slight decrease in the mineralization of organic substances (ash content) (with changes in the head less pronounced than in other portions), was similar to effects on animals after 20-day space flights and indicated the adequacy of the treatment as a model of weightlessness. Similar changes after 40 days were less pronounced, and statistically insignificant. No changes in the diaphysis of the femur were observed. Histological preparations of the diaphysis showed increased porosity (sponginess) of the bone tissue, with increased diameter of Haversian canal after both periods. The diminished width of the cortical layer on the nonsupporting side demonstrated depression of bone formation processes. After 20 and 40 days, the mean level of mineralization in microstructures was equal for the supporting and nonsupporting limbs.

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Administration of calcitriol to group 2 animals increased the density and mineral saturation of the head of the nonsupporting femur compared to the nonsupporting group 1 data, particularly after 40 days. After 20 days the cortical layer of the nonsupporting femur in both projections was narrower than in supporting group 1 limbs, but this difference had disappeared at 40 days. Calcitriol had no effect on the level of mineralization of the microstructure. After 20 days, retabolil was associated with a non-significant increase in density of the head and distal epiphysis of nonsupporting limbs; this effect was no longer evident after 40 days. Animals receiving retabolil (group 3) showed greater decrease in the thickness of the cortical layer than did group 2 animals. Histological data showed decreased osteoporotic thinning of the cortical layer in group 3 animals. No changes in mineralization were associated with retabolil, but there was a tendency for ash content to decrease in the spongy structures. Administration of both drugs led to increased density and mineral saturation of the head and distal epiphysis of the unsupporting femur after both time periods. After 40 days, the mineral saturation of the diaphysis had also increased. Increased ash content of the spongy bone testified to the fact that the drugs normalized mineralization of organic substances. Some thinning of the cortical layer was noted after 20 days, even when both drugs were administered, but this effect was no longer manifest after 40 days. In the combined drug treatment, increases in density of structure were evident on histologic slides and mineralization tended to normalize.

Table 1: Changes in the dimensions of diaphysis cross sections of nonsupporting femurs of rats receiving calcitriol and retabolil, mm

Table 2: Changes in the mineral saturation (in g/cm^2), density (in g/cm^3), and ash content (in %) of femur bone fragments of rats with nonsupporting limbs exposed to calcitriol and retabolil

Table 3: Degree of mineralization (in g/cm^3) of the microstructure of the femur diaphysis of nonsupporting limbs after administration of calcitriol and retabolil (hypokinesia lasting 20 and 40 days)

MUSCULOSKELETAL SYSTEM

P478(11/87)* Grigor'yeva LS, Kozlovskaya IB.

The effect of weightlessness and hypokinesia on muscle velocity-strength relationships in humans.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 27-30; 1987.

[8 references; 1 in English]

Musculoskeletal System, Muscle Velocity-Strength Relationships
Humans

Space Flight, "Salyut-7"; Hypokinesia, Long- and Short-term,
Countermeasures; Head-down Tilt, Long-term

Abstract: Muscle velocity-strength relationships were measured in 14 subjects before and after they had undergone a 120-day period of hypokinesia with head-down tilt, and in 6 members of "Salyut-7" primary crews (flight duration 110-237 days), and 12 members of visiting crews (flight duration 7 days) pre- and postflight. Muscles studied were the antagonist muscle of the calf (the anterior tibia muscle) and the triceps of the calf. Measurements were made using isokinetic dynamometry with angular velocity of motion in the talocrural joint of 180°, 120°, 60° and 0°/sec. Developed moments of force and goniograms were recorded. Results showed that long-term space flight and bed rest with head-down tilt led to significant decreases in the strength parameters of the calf muscles studied throughout the entire range of angular velocities used. Short-term space flight decreased strength to a lesser extent for both muscles studied and at all angular velocities. However, this difference is only marked when angular velocity is 0 (isometric condition). The author argues that this demonstrates the effectiveness of prophylactic measures. This is also demonstrated by the significantly greater decrements in strength found in the hypokinesia condition, where no countermeasures were employed, as compared to long-term space flights. Differences in strength loss for weightlessness and hypokinesia were more pronounced in the triceps of the calf than in the anterior tibia muscle, particularly in the isometric and low-speed condition. The authors argue that the nature of the changes found (e.g., the decrease in both extensor and flexor muscles) as well as other evidence (e.g., length of time to recover muscle strength) implicate atrophic processes in loss of muscle strength after long-term flights. When individual differences were examined it was found that magnitude of loss of strength was correlated with length of time to recover, but not with initial strength. Variance among individuals was twice as great after space flight than after hypokinesia. These results are explained by individual differences in cooperating with prophylactic countermeasures.

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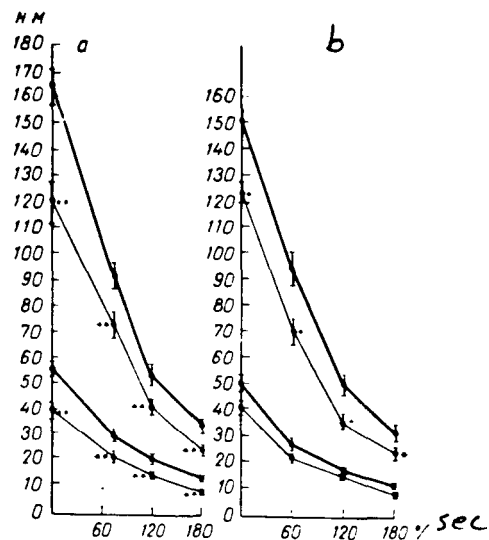


Figure 1. Velocity-strength relationship in calf muscles before and after exposure to different durations of weightlessness

Abscissa-angular velocity of movement (degrees/sec); ordinate - developed moment of force (H·m). a and b - long- and short-term weightlessness, respectively; upper pair of curves - triceps of calf; lower pair - anterior tibia; thick lines - before weightlessness; thin lines - after weightlessness. * difference significant at $P<0.05$, ** $P<0.01$.

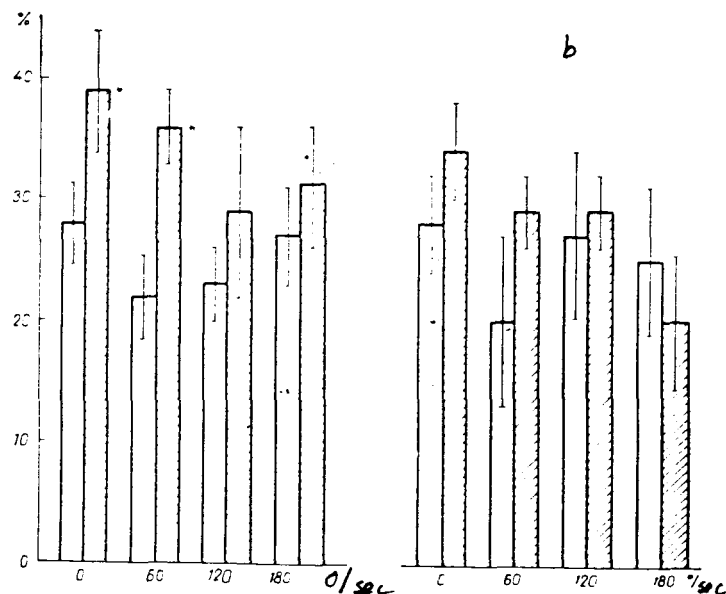


Figure 2: Mean decrease in strength of muscles in the calf at various angular velocities after long-term weightlessness and hypokinesia (with head-down tilt)

Abscissa - angular velocity (deg./sec.); ordinate - decrease in strength (%); a - triceps of calf; b - anterior tibia; white bars - weightlessness; cross-hatched bars - hypokinesia; vertical lines - standard errors; * difference significant at $P<0.05$

MUSCULOSKELETAL SYSTEM

P483(11/87)* Kaplanskiy AS, Durnova GN, Sakharova ZF, Morukov BV.
Effects of diphosphonates on development of osteoporosis in rats undergoing hypokinesia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 47-51; 1987.

[11 references; 8 in English]

Musculoskeletal System, Osteoporosis

Rats, Males

Immobilization; Psychology, Stress; Diphosphonates

Abstract: In this study 47 male Wistar rats were housed in immobilization cages for 60 days. Experimental rats received oral doses of hydroxydimethylaminopropylene diphosphonic acid (HMAPDA) and hydroxyethylene diphosphonic acid (HEDA) in daily doses of 6 and 9 mg respectively per 1 kg body weight. The vivarous control group underwent no experimental treatment, a hypokinesia control was immobilized in cages but received no drugs, and a drug control received drugs but no immobilization. After 60 days the animals were weighed, the lengths of their tails measured (as an indicator of linear growth), and then sacrificed. The tibia bone and the lumbar portion of the spine were isolated and the length of the tibia measured. Bones were fixed, decalcified, and 5 μ m thick cross-sectional slices made and stained. Microscopic and quantitative histomorphometric analyses were performed. The density of primary and secondary spongiosa was determined, the width of the epiphyseal primary cartilaginous growth layer was measured, and numbers of osteoclasts and osteoblasts in 20 fields were counted.

Drugs administered to rats undergoing normal activity had no effect on their weight, growth, or tibia length. However, HMAPDA led to substantial changes in the structure of the bone. In these rats both bones studied showed increases in primary spongiosa density, growth layer width, and width of the primary spongiosa zone, decrease in active osteoblasts, and increase in osteoclasts which included more giant multinucleated cells. No change was found in the secondary spongiosa in either bone. Thus, while HMAPDA led to increased density of primary spongiosa, the newly formed bone tissue differed qualitatively from normal tissue, and the process of mineralization of such tissue could be disrupted. The changes are described as associated with inhibition of bone resorption. Administration of HEDA to normal rats led to changes which were similar in direction but less pronounced than those resulting from HMAPDA. Hypokinesia led to decreases in body weight, growth, density of spongy bone (beginning of osteoporosis), length of the tibia bone, and width of the cartilaginous growth layer and the primary spongiosa zone. No significant changes were seen in the number of osteoclasts or osteoblasts indicating that no major changes in resorption occurred. Administration of HMAPDA to immobilized rats did not have a positive effect on body weight or growth, but did increase density of primary (greater than vivarous control) and secondary spongiosa (equal to control). Width of the cartilaginous growth layer was no different from that of normal rats, while width of primary spongiosa zone was higher. The number of active osteoblasts in the primary spongiosa zone was one-half that of immobilized animals receiving no drugs, and one-quarter of that of normal animals, while the number of osteoclasts increased. Thus, administration of HMAPDA to animals undergoing hypokinesia led to inhibition of both growth and resorption of bone;

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however, since inhibition of resorption was stronger, the density of spongy bone increased. Administration of HEDA also had no effects on body weight or overall growth. In the spine, the only change noted was an increase in secondary spongiosa density. Other parameters were equivalent to those of animals immobilized without drugs. In the tibia, there was a decrease in density and width of the primary spongiosa zone, as well as a decrease in number of active osteoblasts. Density of secondary spongiosa was greater than that of immobilized rats but lower than control levels. Number of osteoclasts was equivalent to controls. Thus, HEDA led to decreased resorption in the spine, while decreases in both resorption and bone formation were noted in the tibia. The authors conclude that HMAPDA is the more effective drug for preventing osteoporosis.

Table 1: Effects of diphosphonates on body weight, length of tail and tibia bone in rats which had undergone 60 days of hypokinesia.

Table 2: Effects of diphosphonates on histomorphometric parameters of tibia bones in rats which had undergone 60 days of hypokinesia

Table 3: Effects of diphosphonates on histomorphometric parameters of the lumbar vertebrae of rats which had undergone 60 days of hypokinesia.

MUSCULOSKELETAL SYSTEM

P501(11/87) Tatarinov AM, Grigor'yev AI, Dzenis VV, Yanson KhA, Oganov VS, Rakhmanov AS.

Changes in the state of tibia bones in humans during hypokinesia with head-down tilt.

Mekhanika Kompozitnykh Materialov.

1986(1): 134-143.

[6 references; none in English]

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Musculoskeletal System, Biomechanical Properties; Mineral Content; Operational Medicine, Diagnosis Techniques, Ultrasound Scanning, Photon Absorptiometry

Humans, Males

Hypokinesia, Head-down Tilt; Countermeasures, Exercise, Drugs

Abstract: The goal of this experiment was investigation of changes in the biomechanical properties of tibia bones of men undergoing long-term hypokinesia with head-down tilt combined with various exercise programs and pharmacological countermeasures. Data on these bones obtained through ultrasound scanning and photon absorptiometry were compared. Subjects were 15 men, aged 19-44, who were undergoing a 120-day period of bed rest with head-down tilt of -5° . Three of these subjects, the controls, received no countermeasures, 3 were given a pharmacological substance (not specified) to prevent the deleterious effects of the treatment, 4 participated in a physical training program, and 4 received both the drug and the training. Bone measurements were made in the baseline period, and at the end of months 1, 2, 3, and 4 of hypokinesia, and 4 days and 1 month after the treatment terminated. All measurements were performed in the morning. Ultrasound scanning measurements were made along the medial surface of the tibia, at 10 zones, each one of which was 1/10th of the total bone length, and was from 3.3 to 4.3 cm. wide, depending on subject. Piezo electric leads were used. Measurements were made 3 times in each zone, with contact between the lead and the calf reestablished each time. This procedure enabled measurement of the speed of propagation of a deflected ultrasound wave in the compact bone tissue of the tibia. Photon absorptiometry was performed using a commercial bone mineral detector in the seventh and eighth zone measured by ultrasound scanning.

Because of substantial individual differences, noted in the baseline period, group differences in ultrasound or photon absorption data were not statistically significant. However, the combined prophylactic measures condition appeared to be associated with the fewest changes in bone parameters over the period. When data for individuals was examined, 3 patterns of change were discerned in parameters over the course of treatment. In some subjects (group I, $n=6$), parameters (mean speed of sound, and mineral content) decreased to a minimum after 1 or 2 months, and then were restored to approximately baseline value by the end of 4 months. In group II subjects ($n=5$) these parameters continued to increase over the course of treatment, and in group III ($n=4$) they decreased steadily. For all groups, direction of change in ultrasound parameters coincided with that of parameters from photon absorptiometry, indicating that ultrasound scanning can provide data about mineral content of bones. Measures of the degree of difference in wave propagation speed in different

MUSCULOSKELETAL SYSTEM

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zones of an individual's tibia are interpreted as indicating adaptation to loading. These values are not correlated with mineral content parameters.

Table: Comparison of the effectiveness of prophylactic measures against changes in ultrasound and absorptiometry parameters for experimental groups

Figure 1: Determination of ultrasound parameters using overall averaged curve of distribution of rate along the length of the bone

Figure 2: Examples of acoustic heterogeneity of the medial surface of the tibia

Figure 3: Averaged curves of ultrasound propagation rate along the length of the bone and standard deviations for the different treatment groups

Figure 4: Changes in ultrasound and photon absorptiometry parameters for treatment groups

Figure 5: Changes in speed along the length of the bone

Figure 6: Changes in ultrasound and photon absorptiometry parameters in groups showing different patterns of change

Figure 7: Distribution of ultrasound parameters in groups showing different patterns of change

Figure 8: Correlation between monthly measurements of change in rate of ultrasound propagation and mineral content of the bones

NEUROPHYSIOLOGY

(See also: Aviation Physiology: P496; Biospherics: BR11; Cardiovascular and Respiratory Systems: P487; Endocrinology: P457; Mathematical Modeling: P460; Radiobiology: P484)

PAPERS:

P449(11/87)* Bodrov VA, Fedoruk AG.

Assessment of the functional state of pilots on the basis of parameters of interhemisphere asymmetry.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
20(6): 18-21; 1986.

[15 references; none in English]

Neurophysiology, Interhemisphere Asymmetry
Humans, Pilots, Norming Study; Personnel Selection
Flight Factors, Acceleration, Hypoxia, Tolerance; Human Performance

Abstract: In the first part of this study percentile norms were developed for interhemisphere asymmetry using a norming population of 438 pilots and students in flight training. The parameter used was the "right ear coefficient" [not further described], evidently derived from performance on a dichotic listening task. In the second part of the study stability of hemispheric dominance was tested in flight crews exposed to two extreme flight factors: acceleration on a centrifuge of 3- to 5-g for 30 seconds (53 pilots), and continual cumulative Coriolis acceleration (15 subjects). In the final portion of the study, 9 operators (pilots?) were exposed to a 6-hour simulated flight, with factors modeled including hypoxia (equivalent to 3500 m), noise of 100 dB, and the requirement to perform a compensatory tracking task and solve logical/arithmetic problems under speed-accuracy instructions. Quality of performance was assessed on the basis of temporal parameters and number of errors. Operators' functional states were assessed on the basis of changes in heart rate, respiration rate, minute respiratory volume, and self-rated general state and mood. In addition, 33 pilots were tested under actual flight conditions. In order to estimate the utility of indicators of interhemisphere asymmetry for predicting flight performance, comparisons were made of asymmetry parameters of flight crewmembers with different tolerance of flight factors and varying task performance levels.

Results of the first portion of the study indicated that a "right ear coefficient" of 2-5% was very low, 6-10% was low, 11-25% was below average, 26-40% was average, 41-50% was above average, 51-65% was high, and greater than 65% was very high (percentile equivalents of descriptors not given.) In general, there was no significant relationship between number of years of flight training for trainees and pilots and the asymmetry parameter. Pilots with the very highest level of flight qualification did have a significantly higher coefficient of asymmetry. The second portion of the study revealed no significant effects of radial acceleration on the asymmetry coefficient. However, it was found that asymmetry tended to increase under acceleration in pilots with high tolerance, but to decrease in those with low tolerance. After Coriolis acceleration, the asymmetry parameter dropped substantially and was accompanied by symptoms of motion sickness. In the third portion of the study, the parameter of asymmetry

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began to drop after 3-4 hours of exposure to the simulated flight conditions, and was less than 40% baseline after 6 hours of exposure. This change was accompanied by growing fatigue, and deterioration of physiological parameters and task performance. After 2 or 3 flights, however, the asymmetry parameter had increased, but to a greater extent in pilots who performed better. The better pilots also had higher initial levels of asymmetry. The authors conclude that marked lateralization of functions in the cerebral hemispheres facilitates greater tolerance of flight factors and a higher level of flight performance. In addition: 1) under exposure to flight factors, increasing asymmetry tends to be associated with high tolerance, and decreasing asymmetry with low tolerance; 2) higher initial asymmetry is also associated with better tolerance; 3) the extent of asymmetry is positively associated with the functional state of the pilot and his task performance. Thus, parameters indicative of interhemisphere asymmetry may be useful in pilot selection.

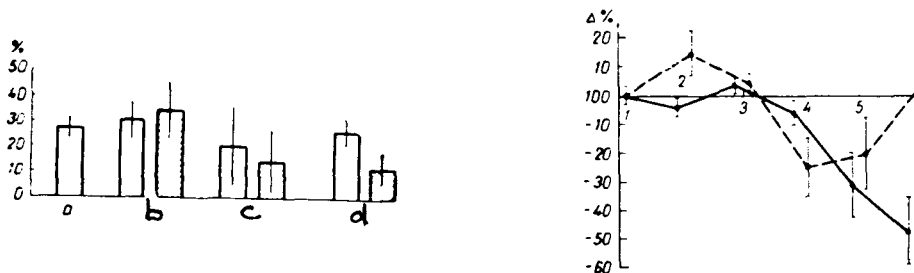


Figure 1: Changes in parameters of functional interhemisphere asymmetry (in %) after exposure to acceleration

a - control; b - pilots with high tolerance of acceleration; c - pilots with low tolerance; d - continual cumulative Coriolis acceleration; white bars - before exposure; cross hatched bars - after exposure.

Figure 2: Changes over time in parameters of interhemisphere asymmetry and quality of task performance during simulated 6-hour flight
unbroken line -- right ear coefficient; dotted line -- performance quality;
abscissa - exposure duration in hours.

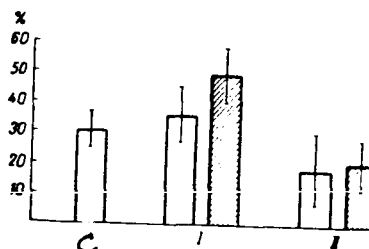


Figure 3: Parameters of interhemisphere asymmetry (in %) in pilots, performing flight tasks well (I) and less well (II).
white bars -- preflight; cross-hatched -- post flight.

P458(11/87)* Zaritskiy VV, Krylov YuV

Effects of altered circulation on human nystagmic reactions.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 58-61; 1986.

[14 references; 4 in English]

Neurophysiology, Nystagmus, Optokinetic Stimulation, Coriolis Acceleration
Humans, Males

Cardiovascular and Respiratory Systems, Altered Circulation, Head-down Tilt

Abstract: Subjects in this experiment were 44 males, aged 19-42, exposed to optokinetic stimulation and Coriolis acceleration while in a head down tilt position (-10°). Optokinetic and vestibular kinetic nystagmic responses were studied. Vestibular stimulation was induced by rotating the tilt table around the vertical axis while the subject was lying on his back in the head-down position; at the same time, the subject's head was moved $\pm 30^{\circ}$ in the sagittal plane at an increasing rate. Optokinetic stimulation was achieved with a rotating disk containing alternating dark and light stripes. Fifteen minutes after a subject assumed the head-down position he was rotated to the left with his eyes closed, to a maximum angular velocity of $120^{\circ}/\text{sec}$. At the same time, the optokinetic disk was rotated to the left at $220^{\circ}/\text{sec}$. After three minutes of rotation at constant rate, the subject opened his eyes and optokinetic nystagmus was recorded for 10 seconds. Next, Coriolis acceleration (involving combined head movement and rotation) commenced and vestibulooptokinetic nystagmus was measured. When the subject began to show symptoms of motion sickness, rotation was stopped and optokinetic nystagmus was recorded again. In addition, the investigators examined the effects of changing the fixation point on the optokinetic disk on parameters of optokinetic nystagmus.

Results showed that induction of motion sickness increased the amplitude and slow-phase rate of optokinetic nystagmus. When the head was moved back and forth between a raised position and a neutral one, resulting vestibulooptokinetic nystagmus was more pronounced than when it was moved back and forth to a lowered position. When subjects were placed in a head-down position, optokinetic nystagmus decreased, especially when they were asked to track an optokinetic stimulus close to the center of the disk. With central fixation, rotation led to further decrease in number of nystagmic eye movements, while amplitude and slow-phase rate remained unchanged. When subjects tracked stimuli further from the center of the disk, the magnitude of all nystagmic parameters increased.

The authors conclude that this series of experiments has revealed a very important phenomenon: modification of optokinetic nystagmus in concurrence with fluid shifts in the cranial direction. Evidently, disruption of hemodynamic stability in the peripheral and central portions of the vestibular system led to changes in vestibular functioning. These results confirm the well-known clinical finding that the vestibular system is highly sensitive to hemodynamic changes, and indirectly suggest that, during the initial period of adaptation to space flight conditions, the hemodynamic factor can alter vestibular functioning and, in combination with other factors, contribute to the development of space motion sickness.

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Table 1: Parameters of optokinetic nystagmus during induction of motion sickness in head-down tilt position

Table 2: Parameters of vestibulooptokinetic nystagmus during visual-vestibular stimulation in head-down position

Table 3: Parameters of optokinetic nystagmus during visual-vestibular stimulation in head-down tilt position (-10° ; $n=17$)

| Condition | Central Fixation | | | Peripheral Fixation | | |
|-----------|---------------------|-----------------------------|--|---------------------|-----------------------------|--|
| | number of movements | amplitude total, $^{\circ}$ | slow phase rate, $^{\circ}/\text{sec}$ | number of movements | amplitude total, $^{\circ}$ | slow phase rate, $^{\circ}/\text{sec}$ |
| I | 32.1 | 71.2 | 16.0 | 30.3 | 127.2 | 27.0 |
| II | 29.1 | 77.0 | 14.2 | 29.0 | 122.1 | 26.3 |
| III | 26.3 | 63.5 | 13.6 | 43.3 | 137.6 | 31.0 |
| IV | 26.1 | 72.6 | 14.9 | 30.1 | 161.4 | 34.8 |
| V | 30.3 | 85.4 | 18.5 | 32.3 | 145.3 | 32.0 |
| VI | 31.5 | 73.3 | 16.0 | 28.1 | 132.2 | 28.4 |

I: horizontal position, no rotation; II: head-down position, no rotation; III: head-down position, rotation at $120^{\circ}/\text{sec}$; IV: head-down position, $120^{\circ}/\text{sec}$; V: head-down position, $120^{\circ}/\text{sec}$; VI: horizontal position, no rotation; I - III, before motion sickness induction; IV - VI after motion sickness induction

P459(11/87)* Trinus KF.

Thresholds of long latency evoked potentials and sensations of movement in humans exposed to linear acceleration.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 62-66; 1986.

[10 references; 7 in English]

Neurophysiology, Long Latency Evoked Potentials, Motion Perception
Humans, Patients, Meniere's Disease, Labyrinthine Areflexia, Neuritis of
Auditory Nerve
Linear Acceleration

Abstract: Subjects in the experiments described here included a total of 47 individuals of both sexes aged 14 to 38, of whom 34 were healthy, 2 suffered from bilateral areflexia of the labyrinths, 4 had Meniere's disease, and 5 suffered from auditory neuritis. In a dark room, subjects were seated in a specially-designed chair which could be raised to produce linear acceleration at different rates. Subjects indicated commencement of sensations of motion by pushing a button in the chair's arm. A computer recorded acceleration rate and subjects' EEGs. EEG records were specifically directed at recording long latency potentials evoked by acceleration. In the first experiment, the threshold value for acceleration giving rise to sensation of movement was studied in healthy subjects. In the second experiment, long latency potentials evoked by acceleration were recorded in a similar population. Experiment 3 evaluated the possible contribution of artifacts and individual sensory and motor systems to the effects. Experiments 4 and 5 were the counterparts of 1 and 2 using the population of patients.

Healthy individuals all experienced 3 types of sensations of movement as linear acceleration increased: a sensation of movement undifferentiated for direction (mean threshold: 8.0 cm/sec^2); a sensation of movement diametrically opposed to actual movement (mean threshold: 12.4 cm/sec^2); and perception of motion in the veridical direction (mean threshold: 16.1 cm/sec^2). Both inter- and intraindividual variability were greatest for threshold for perceiving undifferentiated motion, while variability was lowest for inverted motion threshold, with inter- and intraindividual variability virtually identical. Threshold for perceiving motion veridically showed the greatest difference between inter- and intraindividual variability. When a subgroup of subjects was divided on the basis of whether or not they under- or overestimated objective probability, it was found that those who overestimated had a threshold of perceived movement approximately half of those who underestimated (n's very small). The typical curve of long latency acceleration evoked potentials had two positive and one negative peak. As acceleration increased, latency of peaks decreased. Threshold for evoked potential was set arbitrarily at the point where signal-to-noise ratio was at least 2:1 (5.7 cm/sec^2). As acceleration increased from the evoked potential threshold to the sensation of undifferentiated motion threshold, the greatest latency decrease involved the second positive peak. Increasing acceleration from the undifferentiated to the inverted motion threshold had the greatest effect on all three peak latencies, while increasing acceleration from inverted to correct perceived motion threshold affected the latency of the negative peak more than the others. Effects of motion of EEG leads, and oculomotor- and auditory-evoked potentials were ruled out as responsible for the effect

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observed. Subjects with Meniere's disease showed thresholds of subjective perception of motion similar to the norm, while the latency of peaks contralateral to the affected side increased. Individuals with bilateral hyporeflexia or vestibular pathologies showed increased peak latencies and higher thresholds for perceiving motion.

Table: Values for latent periods of peaks of long-latency potentials evoked by acceleration and their coefficients of variation for different levels of acceleration

Figure 1: Diagram of chair used to produce linear acceleration

Figure 2: Examples of potentials evoked by acceleration in healthy individuals a -- acceleration, in the area of threshold for subjective sensations; b -- accelerations exceeding the ones required for subjective sensations; c - vestibuloocular response to the effects of acceleration

NEUROPHYSIOLOGY

P468(11/87)* Kovalev VYu, Tigranyan RA.

Level of polyamines in the brain of rats undergoing long-term hypokinesia.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 86-87; 1986.

[10 references; 5 in English]

Neurophysiology, Polyamines, Cerebrum, Cerebellum, Medulla Oblongata
Rats

Immobilization; Psychology, Stress

Abstract: Male Wistar rats were confined in immobilization cages for 15, 20, 30, 60, or 90 days, after which the concentrations of polyamines in the medulla oblongata, cerebellum, hypothalamus region, and cerebral hemispheres were determined using ion exchange chromatography followed by electrophoresis. In the medulla oblongata, spermidine was depressed after 20 days of hypokinesia, and putrescine and spermidine after 30 days. After 60 days, polyamines in the medulla were no different from initial values, while after 90 days putrescine and spermidine were again depressed. The only change noted in the cerebellum was depression of spermidine after 20 days. In the hypothalamus region, 15-days of hypokinesia led to depression of spermidine, 20 days to drop in spermidine and spermine; 30 days to drop in all polyamines; 60 days to no changes from baseline; and 90 days to depression of spermidine. In the cerebral hemispheres, all polyamines were depressed relative to control on days 20, 30, and 90 of hypokinesia, while on day 60 polyamines were at baseline levels. These data show that different portions of the brain react differently to hypokinesia, with the cerebrum being most sensitive and the cerebellum least. The authors note that changes in polyamine concentrations appear to be cyclical over the course of long-term hypokinesia with greatest decreases occurring on days 20-30, relative normalization on day 60, and new (but less extreme) decreases on day 90.

P469(11/87)* Tigranyan RA, Vakulina OP.

Response of the opiod system in sympathectomized rats to immobilization stress.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 87-89; 1986.

[14 references; 11 in English]

Neurophysiology, Opioid System, Adrenergic, Cholinergic
Rats, Male, Sympathectomized
Immobilization; Psychology, Stress

Abstract: Male Wistar rats were sympathectomized by intraperitoneal injection of 6-oxydopamine causing reversible degeneration of adrenergic terminals or by injection of this substance into the third brain ventricle destroying the terminals of cholinergic neurons. Control animals were injected in the same sites with a placebo. On day 4 after intraperitoneal injection and day 6 after the brain injection, animals were immobilized on a special stand for 150 minutes and then sacrificed. Radioimmune assay was used to measure concentrations of methionine enkephalin (ME), leucine enkephalin (LE), and beta-endorphin (BE) in the hypothalamus, pituitary, midbrain and medulla, of enkephalins in the striatum, BE in plasma, and ME in the adrenal gland.

After immobilization, rats given the placebo showed a marked increase in the level of opioids in the hypothalamus; LE in the blood increased while it decreased in the pituitary. Rats sympathectomized through intraperitoneal injection of 6-oxydopamine displayed a marked increase in aggression, elevated levels of LE in the striatum, ME in the midbrain and adrenal gland, and BE in the hypothalamus, midbrain, and medulla oblongata before immobilization. After immobilization, level of opioids in the midbrain, medulla and adrenal gland remained elevated; concentration of enkephalins in the pituitary and ME in the hypothalamus increased, while concentration of LE in the striatum and BE in the hypothalamus dropped to control levels. BE increased in the blood, but was unaltered in the pituitary. The authors conclude that destruction of peripheral adrenergic innervation led to changes in the concentration of opioid peptides in the brain, as well as differences in response to immobilization stress. In particular, the opiate structures of the brain stem are activated, which is not a normal response of animals to immobilization.

Injection of 6-oxydopamine into the brain ventricle, led to increases in enkephalin in the hypothalamus, LE in the pituitary and BE in the blood. In contrast to the results previously described, no effects on the endorphinergic systems of the hypothalamus and pituitary were noted, with the exception of an increase in concentration of ME in the hypothalamus. After immobilization, these rats showed decrease in the level of BE in the hypothalamus, midbrain, and medulla, increase in the concentration of LE in the striatum, and especially of ME in the hypothalamus. The authors conclude that under normal conditions the effects of the cholinergic neurons of the brain on the opioid system is negligible; however, under immobilization stress the nature of the response of the opiate system depends on the functional state of cholinergic neurons. At the same time, the absence of changes in the concentration of opioids after central sympathectomy may reflect a new homeostatic level of synthesis and utilization of peptides.

P472(11/87)* Yasnetsov VV, Drozd YuV, Shashkov VS, Ryumin Yul.

On the emetic effects of enkephalin, beta-endorphin, and morphine in cats.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 93-95; 1986.

[9 references; 7 in English]

Neurophysiology, Endogenous Opioid Peptides, Enkephalin, Beta-endorphin,
Morphine

Cats

Emetic Effects

Abstract: This experiment was performed on 15 male cats. Three to 5 days before testing, a cannula was implanted in the fourth ventricle of each animal's brain. EKG and respiration rates were recorded. Experimental sessions involved introducing a solution of 10-300 ug enkephalin, morphine or beta-endorphin into the cannula. Naloxon, a specific antagonist of opiates and opioids, was used to block opiate receptors. Introduction of any of the opioid peptides or morphine caused the cats to vomit one or more times, depending on dose. In doses up to 100 ug, none of the substances affected respiration rate. Administration of leucine-enkephalin led to tachycardia followed by bradycardia. Morphine led to slowed heart rate, while methionine-enkephalin and beta-endorphin had no significant effects on heart rate. When naloxon, was introduced into the brain before administration of the peptides and morphine, an emetic effect was observed in only 1 out of 8 cases (100 ug beta-endorphin), and effects of the opioids and morphine on heart rate were eliminated. The authors interpret these results as indicating that endogenous opioid peptides have emetic effects. They cause vomiting by interacting with receptors in the chemoreceptive trigger zone of the emetic center.

Table: Effects of opioid peptides and morphine on parameters of heart rate and respiration rate in cats during and after vomiting

P489(11/87)* Telezhnikov AV, Bazarov VG, Tsygankov VL, Kulikova MV, Mishchanchuk NS.

A spectral representation of vestibular nystagmus.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1):71-73; 1987.

[3 references; none in English]

Neurophysiology, Vestibular Nystagmus

Humans

Mathematical Modeling, Spectral Analysis

Abstract: This work presents a spectral analysis of electronystagmograms (ENG) obtained using a Barany rotation test with angular velocity of 180° for 20 seconds. The model used postulates that the ENG observed during rotation and at the instant rotation terminates is the sum of a determinate component $f(t)$ and a random component. The spectrum of the discretized determinant component is evaluated by means of a procedure utilizing fast Fourier transforms. Both tonic and clonic nystagmus are analyzed. The authors conclude that in both types of nystagmus, the amplitude of the the first harmonic is virtually independent of the value of the ratio of slow phase duration to rapid phase duration; amplitude of the second harmonic undergoes significant changes as a function of this ratio; while the amplitude of the remaining harmonics can be ignored. For diagnostic purposes, it is desirable to use the frequencies of the first and second harmonics and also the ratio of the square of the amplitude of the second harmonic to that of the first.

Figure 1: Typical segments of clonic and tonic ENG.

Figure 2: Diagram of clonic and tonic nystagmus.

Figure 3: Changes in harmonic components of clonic and tonic nystagmus.

P493(11/87)* Ovsyanik VP, Baykay EA, Gurik VV, Karimov RSh, Udovik SL, Kovalenko LS.

Effect of specific stimulation of the vestibular system on medium latency acoustic evoked potentials.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 80-82; 1987.

[No references]

Neurophysiology, Medium-Latency Acoustic-Evoked Potentials

Humans, Individual Differences

Vestibular Tolerance, Rotation

Abstract: The purpose of this study was analysis of changes in amplitude of medium-latency acoustically evoked potentials before and after vestibular stimulation in individuals with varying degrees of vestibular tolerance. A total of 34 healthy individuals with normal hearing participated. These subjects were divided into 3 groups on the basis of tolerance of vestibular stimulation: group 1 contained 4 subjects with high tolerance; group 2 -- 8 subjects with moderate tolerance; and group 3 -- 22 subjects with low tolerance. The experimental apparatus consisted of a rotating chair, an acoustic signal generator, and a device for recording evoked bioelectric activity. Acoustic stimulation had an intensity of 70 dB and lasted 3.5 msec. Acoustically evoked potentials were measured in all groups 5 times before vestibular stimulation and mean and standard error of amplitude and latent periods most characteristic of the cochleomyogenic component were calculated. Vestibular stimulation involved 2 minutes of rotation with velocity of 180°/sec, followed by a stop with the head inclined forward. After the stop, acoustic stimulation was again given and the derived amplitudes of evoked potentials measured. Subjects in the two less tolerant groups showed reliable differences in at least some parameters of evoked potential before and after vestibular stimulation. No such differences were found in the high-tolerance group [however, there were only 4 subjects in this group]. Differences among groups were also found after repeated cycles of stimulation.

Table: Mean differences, standard error of difference, and significance of difference in amplitude components of medium latency acoustically evoked potential before and after stimulation of the vestibular system in individuals in different groups

Figure 1: Medium-latency acoustically evoked potentials in subject R.K. in response to acoustic stimulus of 70 dB

Figure 2: Typical type of changes in coefficient of difference for amplitude components in individual subjects during and immediately after repeated rotation

P494(11/87)* Ovsyanik VP, Udovik SL.

Long-latency evoked potentials in human exposure to linear acceleration.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 82-86; 1987.

[1 reference; none in English]

Neurophysiology, Cerebral Cortex, Long-Latency Evoked Potentials

Humans, Patients, Vestibular Disorders

Linear Acceleration

Abstract: The goal of this study was to identify complex potentials evoked by linear acceleration in the bioelectric activity of the human cerebral cortex. Acceleration was created using a stomatological chair. Duration of chair movement was 50 to 600 msec, with displacement approximately equal to 1 cm for every 100 msec. Depending on movement duration, acceleration and deceleration lasted 20-30 msec. Electrodes were attached to the subject's head with the active electrode on the vertex, the indifferent one on the mastoid, and the grounding on the forehead. Evoked bioelectric activity was recorded and analyzed by computer from the time acceleration started. A quasioptimal filtration band of 0.1-30 Hz was selected. Conditions I and II involved healthy subjects with heads inclined 10° backwards (I) or 45° to the right or left (II). Conditions III and IV used similar conditions, but subjects suffered from vestibular disorders. Electromagnetic artifacts and effects due to oculomotor potentials were ruled out as causes for these effects. Each subject was tested 3 to 5 times before and after acceleration on a single day or several days. Healthy subjects included 5 women and 8 men, aged 28-45. The 2 subjects used in conditions III and IV suffered from impaired functioning of the labyrinth due to concussion.

It proved possible to identify evoked potentials caused by linear acceleration in human EEGs. Parameters of an individual's potential evoked by a certain set of conditions were reproducible when those conditions were repeated. Three components were identified, a positive, negative and then another positive. In healthy individuals position of the head had a substantial effect on parameters of the evoked potential. Subjects suffering from vestibular dysfunction showed higher latencies for the evoked potential than healthy subjects. Head position produced changes in evoked potential in patients that were opposite to those provoked in healthy subjects, suggesting that the vestibular system plays a role in the occurrence of such evoked potentials.

Table 1: Mean complex evoked potential parameters

Table 2: Qualitative changes in complex evoked potentials for different positions of the head with respect to the vertical

Figure 1: Mean complex evoked potentials in healthy individuals

Figure 2: Complex evoked potentials in subject K.S. in response to upward motion

Figure 3: Complex evoked potentials in subject S.L. in response to upward motion

Figure 4: Mean complex evoked potentials for 2 subjects with functional disorders of the vestibular system

MONOGRAPH:

M104(11/87) Meshman VF.

Vliyaniye vestibulyarnogo apparata na zritel'noy analizator

[The effect of the vestibular apparatus on the visual system].

Moscow: Nauka, 1986.

[87 pages; 431 references]

Affiliation: Book: Institute of Higher Nervous Activity and
Neurophysiology, USSR Academy of Sciences

Key Words: Neurophysiology, Vestibular System; Perception, Visual System,
Bioelectric Activity, Weightlessness

Annotation: This monograph discusses effects of the vestibular apparatus on the visual system, as revealed by the results of electrophysiological studies. The author bases his conclusions on his own results, as well as on data in the literature. He discusses the theoretical aspects of problems such as the organization of mediating structures, specificity and the physiological meaning of vestibular-visual effects.

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NUTRITION

(See also: Body Fluids: P450)

PAPER:

P475(11/87) Gazenko OG.

Space Medicine -- new approaches in the theory and practice of general medicine.

Presentation of the Soviet delegation at the 24th session of the Science and Technology Subcommittee, of the UN Committee on Peaceful Uses of Space.

UN, New York, February, 1987.

Translation of speech text.

Key Words: Nutrition, Trophology; Gastrointestinal System; Metabolism; Microbiology, Intestinal Microflora; Enzymology, Endocrinology, Peptide Hormones; Biospherics; Body Fluids; Equipment and Instrumentation; Operational Medicine

In May of the current year, East Germany will host the next meeting of the nations participating in the Interkosmos program. This meeting will commemorate the 20th anniversary of research collaboration in the area of space biology and medicine.

Over the past two decades, we have succeeded in obtaining extensive and interesting scientific results and practical expertise in medical support of short- and long-term (more than 6 months) space flights.

The scientific results of the session are to be printed and will soon be available to the international science community. I have had the opportunity to look through these results and am convinced that our knowledge of the human body's reactions to space flight has progressed substantially. Of course, many gaps and unsolved problems persist, but the progress is undeniable.

These same results also bear witness to the fact that the ever increasing scope of space medicine continues to enrich and stimulate general medicine.

Those delegations which want to become familiar with the details of this material may request them from "Interkosmos, GDR," which would fully accord with the UN General Assembly's resolution that "all nations must have the opportunity to use the methods developed as a result of medical research in space."

In previous sessions of the Science and Technology Subcommittee, I have already had the opportunity to tell you of those major trends in our research in the area of space medicine which are already being successfully applied in general medicine, or which hold the promise of application in the future.

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You will recall that we discussed such areas as:

- Remote diagnosis
- Apparatus and instrumentation for studying physiologic function
- Methods of functional diagnosis
- Space biotechnology
- Extension of our medical understanding of human beings.

In our reports, Dr. Arnauld Nicogossian and I have cited examples in each of these areas.

With regard to apparatus and instruments, I would like to point out that at the present time, as part of a Soviet-French collaborative research program, the technology for ultrasound scanning of the heart is undergoing improvement, with the goal of facilitating cardiac imaging in two planes (current echocardiography produces images in only one plane), so as to substantially improve the accuracy of methods for evaluating cardiac parameters.

In a collaborative project with Czechoslovakia and the GDR, we have made substantial progress in the creation of portable instruments for assessing human respiration, metabolism, and blood composition. However, I do not want to focus your attention on the properties of new instruments or methods of research. Instead, I would like to tell you about certain new aspects of human physiology, which have added a space perspective to our point of view, so to speak.

The two greatest events in evolution, the emergence of life from the sea to dry land and the assumption of a bipedal stance by human beings entailed the development of structural and functional mechanisms to be used in the never-ending battle with gravity.

Land animals, and humans as well, have been quite successful. Man learned not only to move freely on the Earth's surface, but now, by virtue of his intelligence, he has been able, literally, to overcome Earth's gravity and fly in space, where weightlessness reigns.

It has turned out that weightlessness gives rise to a variety of changes in the human body: height increases by 3-5 cm, body weight typically decreases because of loss of fluid, circulating blood volume and muscle mass decrease accordingly, and there is a loss of a substantial portion of electrolytes, etc. Reactions of the human body to weightlessness are clearly adaptive in nature. They are a response to a new environment -- "an environment without weight."

Because these reactions are not always pleasant and harmless, specialists working in the area of space medicine have been compelled to take measures directed at improving the well-being and work capacity of cosmonauts in space.

The understanding we have acquired about the reactions of the human body to gravitational stimuli enable us to examine from a new perspective, the causes and natures of a number of health disorders and diseases, which are currently quite common in human beings.

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These include:

- certain diseases of the musculoskeletal system, for example, osteochondrosis;
- diseases of the cardiovascular system, associated with the development of edema and hypertensive reactions;
- a fairly extensive class of disorders in the category "motion sickness," including seasickness, air sickness, etc.

Such phenomena as hypokinesia and hypodynamia deserve special mention. Here we are talking about a significant decrease in the level of motor activity, with a number of associated negative consequences: changes in metabolism; development of obesity (increase in body weight), tendency for hypertensive reaction, etc.

Each of the topics I have mentioned in connection with the problem of gravitational physiology merit special consideration from the point of view of their contribution to new approaches to understanding and treating various diseases.

However, these are by no means the only areas where space medicine has contributed to general medicine. The experience and knowledge acquired in this area during the last quarter-century, have revealed new means and more effective methods of maintaining health and optimizing living conditions, in other words, prolonging active and healthy human life.

As an example, I would like to briefly introduce you to a new, recently developed branch of medicine -- trophology. Trophology is the study of general principles of fundamental vital processes of living systems, including humans, such as ingestion, processing, and assimilation of nutrients and other substances essential to life. Trophic bonds include not only all those among the different components of life, but also the linkage between living and inanimate nature, reflecting global processes of transformation of material and energy throughout the Earth's biosphere.

When the space era began, we hypothesized that the major problem of nutrition would involve the form of the food cosmonauts ate under conditions of weightlessness, as related to the storage of foodstuffs and the techniques for getting them to the cosmonauts table.

The first two space flights, made by Gagarin and Titov, respectively, were reassuring. At that time, we felt that we needed to make only limited changes to adapt the usual terrestrial means of providing people with food to space flight conditions.

However, it turned out that things were not quite that simple.

It was discovered that virtually all the cosmonauts lost several kilograms in weight. In some cases, there was weight loss of as much as 7-8 kilograms. As a rule, cosmonauts developed a negative nitrogen balance. Desire for water was inhibited (i.e., the sensation of thirst disappeared), and other changes were noted. However, I will not dwell on the details.

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Serious, goal-directed research performed in this area over the last 20-25 years, utilizing both flight experiments and studies in physiological laboratories and clinics, produced tangible results that radically altered our ideas about the physiology of human digestion.

I find these results extremely interesting and important, not only for cosmonauts, but to all of us who live on the Earth and take nourishment several times a day.

First, I will briefly describe our new discoveries in this extremely ancient field of study, and then I will attempt to demonstrate the practical significance these discoveries have for you and me.

1. Basic types of digestion.

To the two previously known types of digestion, namely:

- extracellular digestion, occurring in the alimentary (digestive) tract,
- intracellular digestion, occurring within a living cell,

we have added two new types:

- intracellular, but in special microscopic vacuoles;
- wall, or membrane, i.e., digestion occurring on the surface of the cells of the gastrointestinal tract.

These discoveries enabled us to develop an integrated picture of the complex processes of lysis and processing of nutritive substances, and their transport from the cavity of the gastrointestinal tract into the blood so as to provide nutrients to all tissues and organs of the body.

2. Defense systems of the gastrointestinal tract.

It should be remembered that ingestion of nutritive substances into the gastrointestinal tract must be considered not only as a means of replenishing the energy and structural reserves of the body, but also as a potential allergic and incursion.

Nature has taken pains to protect us. We have at our disposal a well-developed defense mechanism. We have gained new information about powerful immunological defense systems in the small intestine, augmenting our previous knowledge of the mechanical barrier and protective functions of the liver.

Research is progressing in this area and there is reason to believe that conclusions will be drawn which have practical implications for the conquest of allergic diseases, which, unfortunately, are increasing in number in present-day society.

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3. Nonnutritive fiber (fibroid structures) and digestive function.

It is traditional to divide the food we eat into two major components: nutritive components, which play a role in nourishing the body (metabolism), and ballast, i.e., components of food which are not utilized in metabolism.

The idea of developing completely assimilable food seemed very attractive for supporting long-term space flights, and some progress was made in this direction. However, results of subsequent research clearly showed that food fiber (e.g. cellulose, lignin and others) will always be an important and essential component of space diets.

Dietary fiber, in which fruits and vegetables are particularly rich, is absolutely essential to the body as a whole, as well as to normal functioning of the digestive system. Fiber is an important regulator of the functioning of the digestive tract in maintaining fluid-electrolyte balance, of motor functions of the intestine, and of the interaction of the body with the numerous colonies of microbes inhabiting the digestive tract.

Epidemiological studies performed in a number of countries have demonstrated the connection between absence or decrease in the fiber content of the diets of the most economically developed nations and disorders of cholesterol metabolism, formation of gallstones, and disbacteriosis. At the present time, it has been demonstrated in a number of clinics that many types of gastrointestinal and metabolic pathology can be prevented and treated by introducing more fiber into the diet.

4. Microbiology of the gastrointestinal tract and endoecological problems.

Previous ideas about the harmfulness of microorganisms inhabiting the gastrointestinal tract have been conclusively disproven. Experience with the excessive use of antibiotics and the effects of various extreme conditions, particularly long-term space flight, have demonstrated that marked decreases and changes in intestinal flora have a negative effect on functioning, and in a number of cases have led to disease.

Comparison of sterile animals, devoid of intestinal microorganisms, with normal counterparts has demonstrated that sterile animals have an underdeveloped immune system, display changes in the structure of the digestive tract, and are very sensitive to diets deficient in vitamins and essential amino acids.

We have concluded that support of normal endoecology is one of the more important tasks in medical support of long-term space flight. In this connection we have developed a method for evaluating and regulating cosmonauts' microflora. I think that this type of approach will become more and more common in the practice of general medicine.

If we had more time, it would be easy for me to continue this list of accomplishments in the study of digestion physiology. But now, I will confine myself to a discussion of recently discovered hormones of the digestive tract.

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5. The hormonal system of the digestive tract.

It has recently been shown that, aside from the classic hormones with primarily local effects, the digestive tract also produces hormones with general effects.

The endocrine components of the digestive system produce approximately 30 hormones and hormone-like substances. Among these, particular attention is currently being focused on the polypeptides (opiates), which have effects similar to morphine. It is believed that these endogenous biologically active substances are either antianalgesic, or produce positive emotions related to relaxation and a feeling of satiety. Could this be the reason we are inclined to doze off after a satisfying meal?

Now I would like to briefly summarize what I have said.

1. Space medicine not only solves problems essential for supporting human life in space, but provides an impetus and, in a number of cases, suggests solutions useful for maintaining the health of people on Earth.

2. Historically, we can identify three concepts of human nutrition:

-- the first and most ancient conception involves eating until full, (to the point of satiety);

-- the second, formulated in the first half of this century is the concept of a "balanced" diet, in which the main emphasis is on satisfying ongoing metabolic needs.

3. Now we are witnessing the formulation of a new scientific concept of nutrition, which could be called "the concept of adequate nutrition."

This new concept does not replace conclusions based on previous scientific data, but expands and enriches them with new results, including those obtained in the field of space medicine.

We believe that an approach based totally on balance and the idea of refined food has not proved justified. Remember that a decrease in the proportion of vegetables and fruits in the diet, the utilization of refined (bleached) grain and refined products are factors conducive to the development of many diseases, including those of the digestive and bile tracts, development of obesity, and other disorders.

We hope that the new scientific concepts on which trophology is based will allow us to correct other errors which still persist in the area of human nutrition.

4. I have attempted schematically and briefly to introduce some new results in the area of the physiology of digestion. I touched on some recently discovered types of digestion, the role of barriers and defensive mechanisms in the digestive tract, the significance of fiber for adequate nutrition, and the importance of monitoring the intestinal bacterial pool.

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5. The problem of nourishing human beings throughout their lives requires a high level of technical competence. It is essential that we acquire the skill and knowledge to combine food products, which are produced by manufacturing technology, with specific natural technologies, in other words, with consideration of the organism's actual functional state. Examples are the elimination of substrates to which certain individuals are intolerant (e.g., milk intolerance) or, on the other hand, increase in proportion of certain substances in the diet which can stimulate processes which have been attenuated.

It is essential to change the components of the diet and the dietary regimen as a function of climatic conditions, level of activity, age, and many other variables.

Of course, all this reminds one of the tactics employed by an engineer who is in charge of the operation of a large and complex machine. If we want our living machine to operate long and effectively, we must study natural technology as completely and rigorously as possible.

NUTRITION

P503(11/87) Sergeyev IN, Kim Ren Kha, Blazheyevich NV, Spirichev VB.
Combined effects of vitamin D and E deficiency on calcium metabolism in bone tissue in rats.

Voprosy Pitaniya.

87(1): 39-43; 1987.

[18 references; 12 in English]

Metabolism, Calcium; Musculoskeletal System, Bone Tissue

Rats, Male

Nutrition, Vitamin D, Vitamin E

Abstract: Male Wistar rats divided into 6 groups of 8-10 animals served as subjects in this experiment. During the 4 weeks of the experiment all animals received a semisynthetic diet lacking vitamins D and E and containing 0.6% Ca and 0.6% P. Group 1 received supplements of D and E; group 2 of D alone; group 3 of E alone; group 4 received no supplements; group 5 received E supplements throughout the 4 weeks and D supplements during the last 6 days of the experiment; group 6 received no supplements until the last 6 days when D was given. Vitamin D was administered orally as D₃ in a dose of 0.25 ug per day to animals in group 1 and 2, and 0.5 ug to animals in groups 5 and 6; vitamin E (DL-alpha tocopherol acetate) was given in a dose of 1 mg. Parameters measured were concentration of inorganic phosphorus, and activity of alkaline phosphatase in blood serum, chemical composition and density of bone tissue, Ca concentration in muscle and the heart. Concentration of vitamin E in blood serum was determined using fluorometry and of vitamin D by radioconcurrent protein binding. Ca transport in the small intestine was evaluated on the basis of capacity of sections of the duodenal intestine to absorb ⁴⁵Ca.

Animals not receiving vitamin D showed the usual symptoms of deficiency -- decrease of 25-OH-D in blood serum to trace level, development of hypocalcemia, hypophosphatemia, increase in the activity of alkaline phosphatases in serum, and sharp decrease in active Ca transport in the intestine. Bone tissue showed changes characteristic of accumulation of nonmineralized osteoids; decrease in density of the diaphysis and epiphysis of the femur, and decrease in concentration of Ca and P, with some increase in collagen in the diaphysis and a large increase in the epiphysis. Deficit of vitamin D also raised the accumulation of Ca in the skeletal muscles and heart. Animals not receiving vitamin E showed fewer changes in Ca transport and in bone tissue. There was moderate hypocalcemia, and a tendency for Ca transport in the intestine and Ca concentration in bone to decrease. Concentration of calcium in the skeletal muscles and heart was elevated. Other parameters were normal. Deficiency of vitamins D and E had an additive effect, increasing rachitic changes. Activity of alkaline phosphatase increased, while density and calcium concentration of the diaphysis and epiphysis decreased and collagen accumulated in the epiphysis. When animals with vitamin D deficit were given Vitamin D for 6 days, almost all parameters normalized and normalization was positively correlated with level of 25-OH-D in blood serum. Animals with vitamin E deficit given vitamin D for the last 6 days did not achieve this normalization. The authors conclude that this data suggest that vitamin E affects Ca metabolism and that a deficit in this vitamin is reflected in bone tissue.

Table 1: Blood serum parameters in rats with vitamin D and E deficiency

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Table 2: Ca absorption by the small intestine of rats with vitamin D and E deficiency

Table 3: Chemical composition and density of the diaphysis and distal epiphysis of femurs of rats with vitamin D and E deficiency

Table 4: Concentration of calcium in the skeletal muscles and hearts of rats with vitamin D and E deficiency.

OPERATIONAL MEDICINE

(See also: Adaptation: M105; Biospherics: BR11; Cardiovascular and Respiratory Systems: P486, P487, P488; Aviation Physiology: P496; Nutrition: P475; Mathematical Modeling: P460; Musculoskeletal System: P501; Personnel Selection: P473)

PAPER:

P465(11/87)* Barer AS, Okhobotov AA, Sorokina Yel, Tardov VM.

Pathological effects on organs of the pelvis minor after exposure to long periods of high $+G_z$ acceleration.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 81-82; 1986.

[No references]

Operational Medicine, Prostate

Humans, Males

Acceleration, Long-term, Centrifugation

Abstract: This experiment studied effects of centrifugal acceleration of from 2-9 g with compensatory lower body compression on the prostate gland of 5 healthy men, aged 20-38. Further details of procedure are not specified. In 3 cases out of 9, palpation revealed edema accompanied by atony or thickening of the gland at the periphery. Morphological analysis of prostate secretion showed fresh erythrocytes (up to 12 in a field of vision). Severity of symptoms appeared to vary as a function of g level of acceleration and type of lower body compression. Hemorrhoidal swelling was observed to accompany prostate edema.

P470(11/86)* Chadov VI, Tsvilashvili AS, Iseyev LR.

Probability of developing altitude-decompression sickness as a function of duration of preliminary exposure to hypobaric atmosphere.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 30-33; 1987.

[19 references; 3 in English]

Operational Medicine, Decompression Sickness, Altitude; EVA Simulation
Humans

Adaptation, Hypobaria; Life Support Systems, Pressure

Abstract: Volunteers (number not specified), aged 21-47, participated in this experiment. There were 3 experimental conditions, each one consisting of 2 preliminary stages and 1 main stage, all of which were produced in a barochamber of volume 110 m³. The first preliminary stage, lasting 2 hours, was designed to simulate conditions in the cabin of a spacecraft immediately before launch; in this stage, air pressure was 112 GPa (840 mm Hg). In the second stage, barochamber conditions were intended to simulate conditions during orbital flight with decreased atmospheric pressure and normal partial oxygen pressure. Barochamber pressure was maintained at 733.3 gPa (550 mm Hg) while oxygen concentration was increased to 29-30%. Duration of exposure in this stage was 24 hours in condition I, 18 hours in condition II, and 12 hours in condition III. The main portion of the experiment was intended to simulate conditions during EVA in space suits with working pressure of 0.3 kgf/cm² (293.3 gPa, 220 mm Hg). During this stage, subjects breathed a gas mixture consisting of 95-96% oxygen and 5-4% nitrogen for 6 hours and were required to perform graduated physical work with their arms, which involved moving a special lever back and forth for 40 minutes out of every hour. Energy consumption during this task varied from 4 to 6 calories/minute. Diagnosis of decompression syndrome was based on subjective reports and clinical symptoms. When duration of stay in simulated orbital flight cabin conditions was 24 hours, no subjects (out of 69 trials with 37 subjects) developed symptoms of decompression sickness. A single case of decompression sickness developed (out of 51 trials with 30 subjects) during the 75th minute of simulated EVA, when duration of preliminary exposure was 18 hours. When duration of preliminary exposure was 12 hours, out of 36 trials with 27 different subjects, 6 subjects developed decompression sickness symptoms. None of these symptoms were severe, and in some cases they abated completely after a few minutes of rest. The authors conclude that duration of preliminary exposure to a cabin with a hypobaric normoxic atmosphere should be no less than 18 hours and preferably 24 hours before performance of an EVA in a space suit with working pressure of 0.3 kgf/cm². If the pre-exposure to hypobaria must be shorter, then the suit should have a higher level of working pressure.

Table: Number of cases of altitude decompression sickness in various experimental conditions

OPERATIONAL MEDICINE

CONFERENCE REVIEW:

CR5(11/87)* Sallvon SG.

Problems in evaluating human functional capacities and predicting health.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 12-17.

Report on: First All-Union Conference on "Problems of evaluating human functional capacities and predicting health," held in Moscow, 3-5 December, 1985.

Key Words: Operational Medicine, Health, Prediction; Human Performance, Functional Capacities; Adaptation, Extreme Conditions; Biological Rhythms; Biospherics, Environmental Factors; Equipment and Instrumentation; Immunology; Mathematical Modeling; Psychology

Selected papers presented to the conference.

A.K. Gus'kova evaluated the potential for using clinical observations of the state of health for diagnosing and predicting changes occurring upon exposure to new living and working conditions. Mathematical approaches to determining optimal boundaries of variability from the norm and acceptable frequency of individual changes in state of health were given. V.M. Akhutin described the development of an automated system to evaluate the functional state of an individual in real time.

M.G. Shandal summarized data on establishment of a numerical function describing variation in the public health as a function of the nature and magnitude of a number of environmental factors. Based on this data, he ranked the factors from the standpoint of their influence on public health and presented an empirically based set of recommendations for conserving and improving the healthfulness of the environment. V.V. Venediktov proposed a method for quantitatively evaluating characteristics of individual health in heterogenous cohorts, while R.M. Bayevskiy classified human functional states and evaluated levels of health from the standpoint of the theory of adaptation.

V.S. Koshcheyev argued that it is essential to develop regional programs for research and large-scale social-medical observation in order to develop a nationwide program. To be successful,, such a program requires the use of automated research systems.

The session on methodology considered the issue of criteria in health to assessment. It was argued that such criteria not only must be sensitive whether an individual is currently in a "normal state," but must also take into account whether he displays normal reactions to environmental factors (including extreme factors). This approach is closely related to the issue of adaptive potential. Here it is important to develop criteria for evaluating functional systems at various hierarchical levels of organization so as to develop an information bank about human health. At the same time, it is essential to study man at the level of the entire organism, to gather integrated information about his functional state.

Much emphasis was placed on various multimethod approaches to evaluating human functional capacities. In particular, the session discussed a

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biorhythm-based approach to assessing human functional capacities utilizing the links between the phenomena of adaptation, homeostasis, and circadian rhythms.

S.A. Dushanin described four types of norms: 1) minimal, for distinguishing between normal and pathological states; 2) norms for characterizing mean values in a large population; 3) optimal norms, for expressing ideal values for ensuring human tolerance of environmental factors; and 4) special norms, related to performance of specified demanding jobs.

One subject of discussion was the creation of psychological relaxation and medical recovery stations in industrial enterprises to counteract negative effects of work. Such centers might contain pools, saunas, baths, recreational and aerobic gymnastics facilities, conditioning on special equipment, use of oxygen cocktails, and facilities for group therapy, autogenic training, biofeedback etc. The need to strictly limit use of drugs in maintaining the well-being of healthy individuals was emphasized.

A number of studies stressed the relationship between psychological adaptation to extreme conditions and the functioning of the immune system.

A particularly interesting paper concerned identifying the most useful indicators of the state of an individual exposed to toxic substances. Emphasis was placed on the need to discover general properties of effects of chemical substances on the body in order to establish quantitative functions relating concentration, time, and effects.

Great importance was attached to development of automated research systems to be used in public health studies to: process large volumes of information; control the course of clinical studies; collect and store data; compare the research results with existing information; and construct graphs and tables. Such systems will use recently developed expert systems for automated diagnosis. Use of computers for keeping medical records was also supported.

The conference's recommendations emphasized the need to develop a systems approach to the study of functional capacities of healthy human beings and prediction of state of health. Such an approach must take into account the interaction between humans and the environment, and the multiple levels on which the body's functional systems are regulated. Criteria for the health of various age and occupational groups must be defined, and occupational adaptation of various population groups must be studied in order to provide a basis for determining the best ways to optimize job performance. Regional adaptation must be studied from a perspective that recognizes the entire complex of climatic, geographical, social, and economic conditions, as well as the selectivity of migration. Other critical topics for further research include evaluation and prediction of human health and functional capacity in an altered functional state, and human functional reserves during work under adverse conditions. Information must be gathered to provide a basis for finding ways to maintain, restore, and increase functional capacities and health. Automated systems must be developed to evaluate and predict functional state and health in the context of providing health maintenance examinations to the entire population.

PERCEPTION

(See also: Aviation Physiology: P496; Human Performance: P498;
Neurophysiology: M104)

PAPER:

P500(11/87) Oshchepkov NA, Lyashchukova SM.

The effects of light (color and brightness) on the visual system during performance of spacecraft-orienting tasks.

Psikhologicheskiy Zhurnal.

7(6): 46-49; 1986.

[9 references; none in English]

Perception, Visual Recovery Time; Human Performance, Astroorientation
Humans, Cosmonauts

Equipment and Instrumentation, Spacecraft Console, Visual Display,
Brightness, Color, Duration

Abstract: The purpose of this research was to obtain data for standardizing brightness of information displays used in astroorientation on manned spacecraft. The first experiment was designed to generate information on effects of color, brightness, and duration of a light display on visual recovery time. This experiment was performed in a darkened room. The experimental apparatus consisted of a simulation of the operator's console (similar to that which displays orientation information on a spacecraft) with interchangeable electroluminescent display cassettes in red, yellow, or green, a display of stars at (+4) stellar magnitude, and a fixation device. The console and the star simulator were in the visual field at the same time and both were viewed binocularly. Subjects' task was to look at the display which flashed at a given brightness, color, and duration and then identify stars on the star display. Visual recovery time was defined as the time elapsed between the flash and the point at which a subject could reliably distinguish a point source of light equivalent to a star of +4 magnitude. Distances from the star simulator were chosen so that the illumination on the pupil was $E=6.65 \cdot 10^{18}$ lux. Brightnesses used were 1, 3, 5, and 10 kJ/M², and the illumination durations were 5, 20, and 15 seconds. The second experiment attempted a more faithful simulation of conditions on board a spacecraft. The following differences were introduced: dark adaptation occurred not only to complete darkness, but to cabin-like illumination of 20 lux; display illumination was not constant and was predominantly green; to look from the display to the star simulator, the subjects had to turn their heads; instead of the full illumination of the retina in the first experiment, this experiment used partial illumination of both the central and peripheral portions of the retina; stars were viewed monocularly; the background against which the stars were presented was illuminated at either 0.05 kJ/M² or 0; the operator's console was positioned so that when star sighting occurred the light from the display fell on the periphery of the retina. Results are shown in Figures 1 and 2.

Results of the first experiment showed that as brightness increases differences in effects of color on visual recovery time become more pronounced. Recovery was faster after a red light display than after green light. Results of the second experiment showed that for low illumination duration ($t < 10$ sec), visual recovery time is only weakly affected by illumination duration, and depends mainly on brightness.

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When illumination times were increased, duration did a have strong effect on recovery time. At low display illumination brightness and duration, the presence of background illumination increases recovery time somewhat. With high display illumination brightness and duration, background illumination decreases recovery time. The authors recommend that if visual recovery time must be decreased, then either brightness or duration of the display should be reduced, or green light displays excluded.

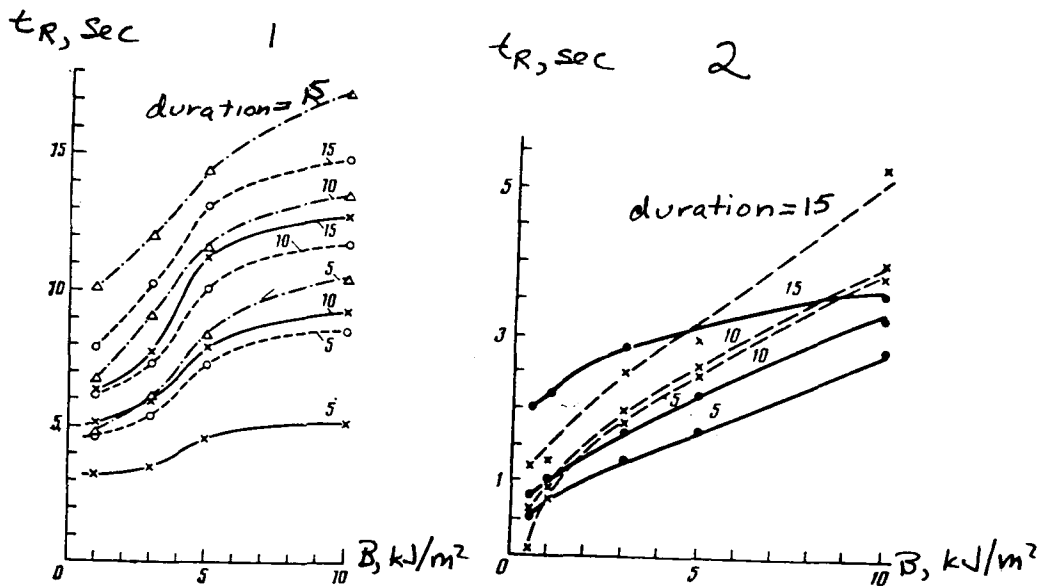


Figure 1: Light sensitivity recovery time as a function of brightness and duration of display illumination for three different color light displays
+ - red light; o - yellow light; - green light

Figure 2: Light sensitivity recovery time as a function of brightness and duration of display illumination for two levels of background brightness
dotted line - background illumination = 0; solid line - background illumination = 0.05 kJ/m^2

PERSONNEL SELECTION

(See also: Aviation Physiology: P496; Neurophysiology: P449)

PAPER:

P473(11/87)* Vyadro MD, Bryanov II.

Development of the Soviet system for medical selection of cosmonauts (hospital stage).

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 3-7; 1986.

[12 references; 6 in English]

Personnel Selection, Review Article; Cosmonaut Training

Humans, Cosmonauts

Operational Medicine, Medical Criteria, Stress Tests; Psychology, Selection Tests

Abstract: This review article discusses in general terms the development of the so-called "hospital" stage in Soviet cosmonaut selection. The initial phase of the hospital stage is analogous to flight certification and is performed by a special commission specializing in fighter aviation. Only pilots 35 or younger are considered and must be fully flight certified for fighter aircraft before moving on to the next stage. Additional tests used for cosmonauts include: centrifugation producing high levels of cranio-caudal and transverse acceleration; vibration stand test; special additional study of the vestibular system; and use of a new set of psychological tests. In the subsequent hospital stage of cosmonaut selection, surviving candidates undergo in-depth and dynamic clinical physiological examinations using state-of-the-art methods and a variety of stress tests which enable thorough and detailed evaluation of physical and psychological capabilities. The purposes of these tests is to ascertain the potential cosmonaut's tolerance of extreme factors. An additional factor assessed at this stage is the cosmonauts' commitment to going into space and their willingness and ability to focus their efforts on meeting standards for performing space missions. Initially, some potential cosmonauts refused to enter the second phase of selection, fearing to lose their flight certification. However, after a mass propaganda campaign begun in 1961, this trend reversed and some candidates attempted to conceal aspects of their medical history which would have tended to disqualify them.

Cosmonauts who pass the hospital stage are sent to the Cosmonaut Training Center for special biomedical training and physical conditioning. Medical information gained in the course of this training has been used to further improve the previous hospital stage of selection. Three medical conditions which tend to degrade during training -- chronic tonsillitis, tooth decay and incipient periodontal disease, and propensity for inguinal hernia -- were selected for attention in hospital selection. However, at least the first and third of these are considered surgically correctable and thus not causes for permanent disqualification. An additional improvement which was introduced into the hospital stage on the basis of operational experience with cosmonaut selection involved reordering tests so that those likely to disqualify the greatest number of candidates are administered first.

PERSONNEL SELECTION

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The author goes on to discuss the fact that medical requirements for cosmonaut-scientists may in the future be relaxed somewhat. Similarities noted between the space selection process in the US and USSR include: 1) use of pilots as candidates for selection; 2) system based on flight certification process; 3) cosmonaut selection as an autonomous scientific area; 4) both systems perform approximately the same number of tests. Minor differences cited involve the greater emphasis in the US on psychiatric research using a large number of psychological tests, and on identifying latent diabetes.

PSYCHOLOGY

(See also: Adaptation: M105; Aviation Physiology: P496; Gastrointestinal System: P455; Group Dynamics: P466; Hematology: P502; Human Performance: All Entries; Musculoskeletal System: P454; P483 Neurophysiology: P468, P469; Operational Medicine: CR5; Personnel Selection: P473)

PAPER:

P499(11/87) Medvedev VI, Zav'yalova YeK, Polikarpova MV.

Mechanism underlying voluntary and involuntary regulation of human performance under extreme conditions.

Fiziologiya Cheloveka.

13(1): 90-95; 1987.

[9 references; none in English]

Authors' affiliation: S.M. Kirova Academy of Military Medicine, Leningrad.

Psychology, Learning, Conditioning, Voluntary and Involuntary Control;
Human Performance

Humans

Sleep Deprivation; Drugs, Stimulants

Abstract: This study involved: 1) determination of the relationship between extinguishing the orienting reflex and developing an optimal mode of performance at the voluntary and involuntary levels; 2) investigation of whether learning can take place on an involuntary level and determination of its role in organizing adaptive behavior; 3) study of these processes under extreme conditions (48 hours of sleep deprivation); 4) examination of the possibility of using drugs to compensate for effects of sleep deprivation. The experiment was run by computer. Stimuli were produced by a light board with 8 lamps of four different colors and a sound signal that varied between 800-1200 Hz. At a fixed rate, pairs of lamps were illuminated; illumination of 3 of the 6 possible pairs of light signals were preceded by a sound, with each pair of colored lights paired with a particular frequency. The task of the subject was to react to the illumination of either of 2 pairs (one with, one without sound signal) with 1 press of a lever; to either of 2 other pairs with 2 presses; and to the 2 remaining pairs with no response. Subjects kept their middle fingers on the lever and full presses and involuntary slight movements (orienting reflexes) were recorded. Dependent variables included: 1) reaction time to light pairs with and without preceding sound signal; 2) number of misses and false alarms; 3) difference in reaction time between early and late trials as a measure of degree of learning; 4) number of involuntary (not completed) responses to the positive light pairs with and without preceding sound; 5) number of involuntary reactions to the negative pairs. Subjects were 9 healthy males, aged 25-30. Experimental sessions occurred in the day, either under normal conditions or after 48 hours of sleep deprivation. During one 48-hour sleep deprivation test, subjects received the stimulant sydnocarb (4 doses totaling 70 mg); in the other test a placebo.

Under normal conditions, reaction time to signals with sounds was higher; these signals evoked more misses and false alarms, and learning was slower than for signals without sounds. However, incomplete orienting reactions were greater for signals with sound. Since verbal instructions (learning stimuli) referred only to light and not sound, the author concludes that

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the pattern of results suggests that the learning process is under conscious (verbal) control under normal conditions. Under sleep deprivation (with placebo), mean reaction time to signals with sound was lower, fewer misses were recorded, and learning rate was much faster than for pairs without sound. However, more false alarms occurred with signals preceded by sound. Orienting reflexes were greater for signals with sound. The authors interpret these results as suggesting that under sleep deprivation the importance of voluntary reactions decreases and thus the role of involuntary (orienting) responses increases in the learning process. Sydnocarb decreased all orienting reflexes and virtually equalized learning rate and response time to both types of signals. The effect of this stimulant is described as restoring the voluntary component of learning and suppressing the involuntary component.

Figure 1: Flow chart of automated programmable bimodal signal generator

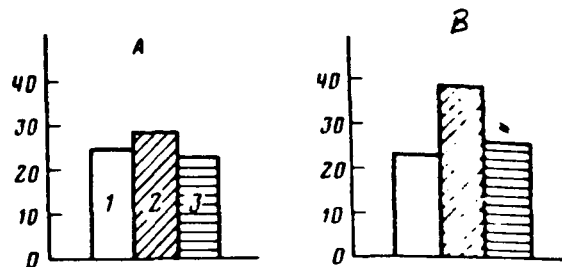


Figure 2: Reaction time to light signals. Here and in remaining figures (A - with sound; B - without sound). 1 - normal conditions; 2 - sleep deprivation + placebo; 3 - sleep deprivation + sydnocarb; * difference from placebo condition significant, $P < 0.05$

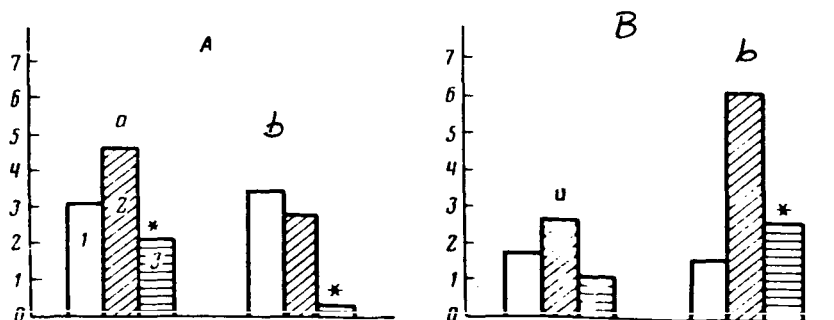


Figure 3: Number of false alarms (a) and misses (b) to light signals.

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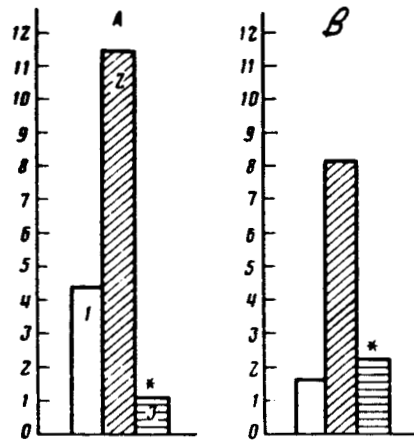


Figure 4. Number of incomplete responses.

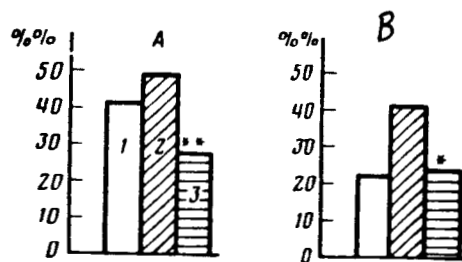


Figure 5. Number of reactions to neutral signals

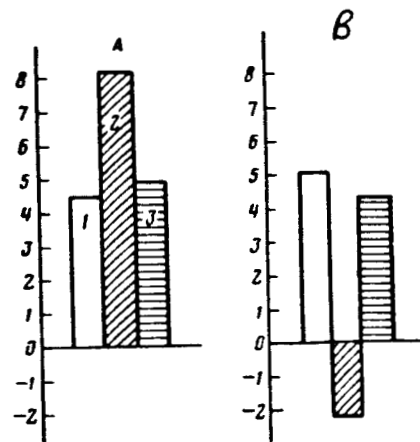


Figure 6. Learning measure for differential response to light signals (difference between reaction time to first and last trials)

MONOGRAPH:

M107(11/87) Khachatur'yants LS, Khrunov YeV.
Pobezhdaya Nevesomost'
[Conquering Weightlessness]
Moscow: Znaniye: 1985
[144 pages, 5 references]

Key Words: Psychology, Psychophysiology; Human Performance, Cosmonaut Performance

Annotation: The authors of this book are specialists in the area of the psychophysiology of cosmonaut performance. They discuss the technological and emotional aspects of space research, and the effects of physical and emotional factors on cosmonauts' bodies, cite scientific data concerning cosmonaut performance, and describe the economic significance of space. This book is intended for a broad range of readers.

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The psychophysiology of cosmonaut performance (present and future) (127)

References (142)

RADIOBIOLOGY

(See also: Biospherics: BR11; Botany: P504; Endocrinology: P461)

PAPERS:

P462(11/87)* Pantev TP, Minkova MI (Bulgaria)

Direct and indirect effects of a constant magnetic field on biological subjects.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 73-76; 1986.

[18 references; 2 in English]

Growth, Survival; Hematology, Leukocytes

Microbiology, Bacteria; Rats

Radiobiology, X-rays, Gamma-radiation; Radioprotective Effects, Constant Magnetic Field, Direct and Indirect Effects

Abstract: Direct effects of a constant magnetic field with intensity of $(2-3) \cdot 10^5$ A/m at 37° on cultures of E.coli B bacteria were studied after 1, 3, 4, 5, and 24 hours of exposure. In another variant, the culture was placed in a broth which had been previously exposed to the field for 18, 24, and 48 hours and then cultured without further exposure. In the next experiment, a bacterial suspension was exposed to the field for 24, 48 and 72 hours at room temperature and then irradiated in a dose ranging from 50-600 Gy. After 48 hours, the colony-forming capacity of the cells was determined. Indirect effects of magnetic fields were studied in rats using magnetically activated water produced by passing tap water through the field described above. In the first rat experiment, animals were divided into two groups, the first of which was given magnetically activated water for 42 days while the other drank ordinary water. Next, both groups were exposed to a single lethal dose of X-rays (8.5 Gy), and were subsequently observed for mortality over a 30-day period during which both groups drank ordinary water. In the second rat experiment, animals drank magnetically activated water for 90 days, then were subjected to gamma-irradiation at a dose rate of 0.01 Gy/hr (0.23 Gy/day) for 52 days. Before and after irradiation, the experimenters measured body weight, osmotic resistance of erythrocytes, and concentration of nucleic acids in leukocytes of peripheral blood. Experimental animals were compared to a control group exposed to irradiation, but drinking tap water.

The magnetic field had no effect on the growth cycle of the culture. Culturing cells in a magnetically processed nutritive medium increased the growth of the bacteria. Preliminary exposure to a magnetic field significantly altered cell response to irradiation. Cells exposed for 1 or 2 days showed increased resistance, while cells exposed for 3 days increased in sensitivity. Drinking magnetically treated water for 42 days slowed weight gain, and increased longevity (however, all rats eventually died) after a lethal dose of radiation. In the second experiment, animals drinking magnetically treated water gained weight more slowly, but showed no differences in leukocytes from animals drinking ordinary water. Fifty-two days of low dose gamma irradiation caused control animals to lose weight, while animals drinking magnetic water continued to gain. Starting at the beginning of gamma irradiation and continuing to the end of the 270-day observation period, experimental animals showed a greater number of

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leukocytes than control counterparts. In addition, animals drinking magnetically treated water showed increased erythrocyte stability. Chronic irradiation caused the concentration of nucleic acid to drop in the leukocytes of both groups, but this effect was more pronounced in the experimental group. It is concluded that direct and indirect exposure to a constant magnetic field can decrease sensitivity to ionizing radiation in moderate and sublethal doses.

Figure 1: Mortality of control rats and rats drinking magnetically activated water after gamma-irradiation

Figure 2: Effect of magnetically treated water on body weight and total number of leukocytes in rats before and after long-term gamma-irradiation

Figure 3: Change in osmotic resistance of erythrocytes and concentration of nucleic acid and leukocytes of normal animals and animals undergoing long-term irradiation

RADIOBIOLOGY

P470(11/87)* Minkova MI, Pantev TP (Bulgaria).

Radiosensitivity of intestinal bacilli after exposure to a constant magnetic field.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(6): 90-91; 1986.

[9 references; 1 in English]

Radiobiology, Radiation Tolerance, Survival

Microbiology; Gastrointestinal System, E. coli B Bacteria

Ionizing Radiation; Radioprotective Effects, Constant Magnetic Field

Abstract: E. coli B were suspended in a saline solution and were placed between the poles of a constant magnetic field with field strength of $2.3 \cdot 10^5$ A/m for 24, 48, and 72 hours and then exposed to radiation of 50-600 Gy at a dose rate of 8.17 Gy/min from ^{60}Co . Survival rate of bacteria in agar at 37°C was then evaluated over 48 hours. In another condition, colony-forming activity of the cells was investigated 1, 3, 4, 5, and 24 hours after exposure of a bouillon culture to the constant magnetic field. In a third condition, cells were exposed to the field after irradiation. The authors state that exposure to the constant magnetic field affected the growth of the bacterial cells, but this is not evident from the graph. Exposure of the bacterial cells to the field for 24 and 48 hours significantly increased their radiation tolerance for both durations. However, exposure to the magnetic field for 72 hours decreased radiation tolerance sharply. Exposure to the constant magnetic field after gamma irradiation had no effect on radio sensitivity. The authors conclude that under some conditions, a constant magnetic field can have a radioprotective effect on bacteria. Magnitude and direction of the effect depend on length of exposure to the field. The effect decreases as duration of exposure to the field increases, and exposure of sufficiently long duration increases radiation sensitivity.

Figure 1: Effect of a constant magnetic field on reproductive capacity of E. coli B bacteria

Figure 2: Changes in radiosensitivity in E. coli B bacteria exposed to a constant magnetic field for 24 and 48 hours before gamma irradiation

Figure 3: Changes in radiosensitivity of E. coli B bacteria exposed to a constant magnetic field for 72 hours before gamma-irradiation

RADIOBIOLOGY

P477(11/87)* Minkova MI, Pantev TP, Talash M, Batkay L (Bulgaria).
Radioprotective effect of insoluble polyanion in prolonged exposure to gamma-irradiation.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.
 20(6): 92-93; 1986.

[4 references; none in English]

Hematology, Spleen, Bone Marrow
 Mice, Male

Radiobiology, Gamma-radiation; Radioprotective Effects, Polyanion

Abstract: In this experiment, male mice were irradiated using ^{137}Cs at a dose rate of 0.74 R/min. to a total of 5 and 10 Gy. A single dose (4mg/kg) of polyanion (Hungarian patented drug) was injected intraperitoneally 1 or 3 hours after irradiation. Three days afterwards animals were sacrificed and weight, total and specific cellularity of the spleen, number of myelocaryocytes in the femur, and total number of leukocytes in peripheral blood were measured. There were 10 rats in each group, including a control receiving radiation and no polyanion. Results of the experiment are shown in the table. The authors conclude that polyanion has a radioprotective effect on the spleen and bone marrow, decreasing the extent of early radiation damage of hemopoietic tissue. This effect occurred under all the conditions but was most pronounced when the drug was administered 3 hours after irradiation.

Table: The effect of insoluble polyanion on mice undergoing prolonged irradiation with gamma-rays from $^{137}\text{-cesium}$ (0.74 R/min., dose of 5 and 10 Gy)

| Parameter | Radiation dose, Gy | | |
|---|--------------------|---------------------|---------------|
| | 5 | | |
| | Control | Polyanion (4 mg/kg) | |
| | | 1 hour later | 3 hours later |
| Spleen weight, mg | 61.40 | 61.75 | 112.18* |
| Total cellularity of spleen, 10^6 per organ | 92.48 | 65.82* | 125.54* |
| Specific cellularity of spleen, 10^6 per 1 mg | 1.31* | 1.06* | 1.31* |
| Total number myelocaryocytes, 10^6 per femur | 9.12 | 6.50* | 11.00* |
| Blood leukocytes | 5300 | 5700 | 3800* |

| Parameter | Radiation dose, Gy | | |
|---|--------------------|---------------------|---------------|
| | 10 | | |
| | Control | Polyanion (4 mg/kg) | |
| | | 1 hour later | 3 hours later |
| Spleen weight, mg | 46.00 | 38.66 | 42.66 |
| Total cellularity of spleen, 10^6 per organ | 38.37 | 50.37* | 50.50* |
| Specific cellularity of spleen, 10^6 per 1 mg | 0.76* | 0.92* | 1.10* |
| Total number myelocaryocytes, 10^6 per femur | 3.29 | 3.38 | 6.10* |
| Blood leukocytes | 1600 | 2100* | 1900 |

* presumably indicates statistical significance of differences, but authors do not specify which differences or significance level.

P484(11/87)* Fedorenko BS, Kabitsyna RA, Krivitskaya GN, Derevyagin VI, Ryzhov NI.

[Study of the] Frequency of morphological changes in neurons in the cerebral cortex of rats exposed to accelerated carbon ions.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

21(1): 51-55; 1987.

[6 references; 2 in English]

Neurophysiology, Cerebral Neurons

Rats, Female

Radiobiology, HZE, Gamma Radiation

Abstract: Experiments were performed on mature female Wistar rats divided into 4 groups. The first group was irradiated with accelerated carbon ions (LET=120 MeVcm²/g) with flux density of 10⁴ per 1 cm². Group 2 rats were irradiated with gamma rays in a dose of 1 Gy with dose rate of 0.024 Gy/sec) and then a day later with a bundle of carbon ions; group 3 was irradiated with the gamma rays alone; and group 4, the control, was untreated. After 1 or 3 months, the subjects were sacrificed and cross-sections were obtained, fixed, and stained for histological examination. Quantitative analysis was performed of destruction in the neurons of the cerebral cortex. In each animal, 3000 neurons were examined and the number of unchanged neurons, neurons with readily reversible (morphofunctional and compensatory adaptive) changes, and those with dystrophic (including necrobiotic and necrotic) changes counted. In addition, a profile field [seems to mean average size] of cell bodies and nuclei in the V layer (Betz) cells was computed, along with the nucleus-cytoplasm ratio and the glioneuronal index.

One and 3 months after irradiation, small sites of cellular destruction were observed in layers II and III of the cortex. There was an increase in the number of contiguous neurons, cells with large clumps of basophilic substance, and 2- and 3-nuclei cells, particularly in animals in group 1. After 1 month, more dystrophic changes were noted in animals in groups 1 and 2 than in groups 3 (gamma-radiation alone) and 4 (control). After 3 months number of dystrophically altered neurons tended to decrease, but these changes were still more pronounced in groups 1 and 2. After 1 month number of slightly altered cells was greater in group 2 than in other groups; after 3 months, number of slightly altered cells was comparable to control in all experimental groups. One month after irradiation the profile field of the body and nuclei of cells was half the size in animals in group 2 than in the other groups. In this group the cytoplasm:nucleus ratio was lower than in the others, indicating a rather high level of functional activity. In group 3 animals the profile field of the cell body increased while that of the nucleus decreased leading to an increase of the cytoplasm:nucleus ratio and suggesting decreased functional activity. After 3 months the value of this ratio had dropped considerably in group 3 but was still above the other groups; group 1 animals showed the lowest cytoplasm:nucleus ratio. After 1 month the glioneuronal index was lower for groups 1 and 2 than for 3 and 4. After 3 months, the indices for groups 1 and 4 were higher than for 2 and 3.

These results are interpreted as indicating that effects of accelerated carbon ions on neurons are more pronounced than effects of gamma-radiation.

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Table: Quantitative analysis of structural changes in neurons of the cerebral cortex in rats 1 and 3 months after exposure to accelerated carbon ions and gamma-irradiation

Figure 1: Morphological changes in neurons 3 months after irradiation with carbon ions

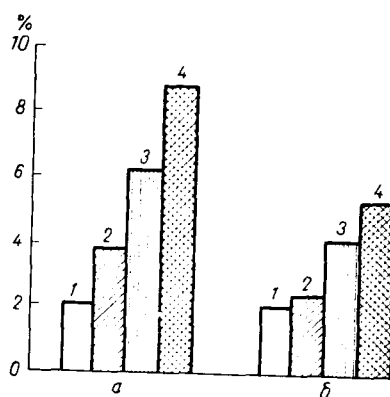


Figure 2. Number of dystrophic changes in neurons of the cerebral cortex of rats 1 (a) and 3 (b) months after irradiation. 1 -- control animals; 2 -- gamma-irradiation 1.0 Gy; 3 -- carbon ions 10^4 particles per 1 cm^2 ; 4 -- gamma irradiation and carbon ions.

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USSR REPORT: SPACE BIOLOGY AND AEROSPACE MEDICINE VOL 20, NO 5 SEPTEMBER-OCTOBER 1986

JPRS-USB-86-007 16 December 1986

This report was abstracted in Issue 10 (March 1987) of the USSR Space Life Sciences Digest.

USSR REPORT: LIFE SCIENCES BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-86-022 5 December 1986

Selected Contents:

Possible Use of Plasmids for Study of Effect of Space Flight Factors on Biological Objects (S.N. Zaloguyev et al.; journal article translation; 9 pages)

Zero Gravity and Living Organisms (TASS; newspaper article translation; 1 page)

Biorhythmic Aspects of Intercontinental Antarctic Adaptation (A. L. Maksimov et al.; journal article translation; 7 pages)

General Biological Character of Adaptive Capacity of Mammalian Metabolism In Response to Diverse and Extreme Environmental Factors (B.M. Grayevskaya et al, journal article abstract; 1 page)

Protection Against Radiation in Chernobyl (V. Romanenko; journal article translation; 5 pages)

Effects of Ionizing Radiation on GABA System and GABA-coupled Reactions in Brain (I.V. Savitskiy et al.; journal article abstract; 1 page)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-002 6 February 1987

Selected Contents:

Effects of Adaptation to High-Altitude Hypoxia on Microcirculation in Rats with Early Stages of Burn Trauma (Yu.M. Shtykhno, et al.; journal article abstract; 1 page)

Effect of Kallikrein on Development of General Adaptation Syndrome (Yu. V. Koleda, et al.; journal article abstract; 1 page)

USSR REPORT: LIFE SCIENCES
BIOMEDICAL AND BEHAVIORAL SCIENCES

JPRS-UBB-87-004 18 February 1987

Selected Contents:

Effects of Hypokinesia on Calcium Absorption in Rat Small Intestine (I.N. Sergeev, et al.; journal article abstract; 1 page)

Effects of Diets with Active Vitamin D₃ Metabolite and Varying Calcium and Phosphorus Content on Composition of Free Amino Acids in Blood of Hypokinetic Rats (T.G.Vlasova, et al.; journal article abstract; 1 page)

Use of Gravitational Overloads as a Screening Procedure in Research on New Biologically Active Agents (M.D. Gayevyy; journal article translation; 2 pages)

Comparative Study of Individual and Combined Effects of Trental, Menthol, and Obsidan on Cardio-respiratory System of Operators Under Extreme Conditions (L.D. Makoyeva; journal article translation; 4 pages)

USSR REPORT: SPACE

JPRS-USP-87-001 19 FEBRUARY 1987

Selected Contents:

TASS Report on Flights of Unmanned 'MIR' and 'Salyut-7' Stations (TASS; newspaper report; 1 page)

Crew Named for Soviet-Syrian Manned Mission (newspaper report; 1 page)

Cosmonaut Crews for USSR-Syria Flight Presented (television broadcast text; 3 pages)

Soviet-French Meeting on Plans for 1988 Joint Manned Mission (newspaper report; 1 page)

Memorandum on 1988 Soviet-Bulgarian Manned Mission Signed (newspaper report; 1 page)

Development of Repair Operations in Orbit (Chernyshev; English journal article reproduction; 3 pages)

Year-long Hypokinesia Experiment in Progress (2 journal article translations; 8 pages)

IZVESTIYA Commentary on Hypokinesia Experiment (newspaper article translation; 5 pages)

Hypokinesia Experiment Passes Halfway Point (L. Repin; newspaper article translation; 6 pages)

Medical Research Planned for USSR-France Manned Mission (Grigoryev; newspaper article abstract; 1 page)

Gazenko Comments on Biological Life Support Systems for Spaceflight (newspaper article abstract; 1 page)

Radio Radiation and Microwaves: Operator Radiation Safety (B.I. Davydov; journal article abstract; 1 page)

Variation of Growth Response of Lettuce Plants as a Function of Spaceflight Exposure Time of Seeds on Board Salyut-7 Manned Orbital Station (A.T. Miller, L.V. Nevzgodina; journal article abstract; 1 page)

Study of Physiological Processes in Lettuce Seeds After Damage by Heavy Charged Particles (A.T. Miller, et al.; journal article abstract; 1 page)

Photographic Method for Studying Spectral Reflectance of Vegetation Cover (A.E. Kuusk; journal article abstract; 1 page)

Effectiveness of Utilization of Space-derived Information in Forestry Management (V.V. Yezhkov, et al., journal article abstract; 1 page)

Remote Spectrometric Methods for Evaluation State of Winter Rye After Wintering Over (S.F. Buga, et al.; journal article abstract; 1 page)

Study of Reflectance Parameters of Fields of Winter Wheat in Various States (A.D. Dobrozrakov, et al.; journal article abstract; 1 page)

Possibilities of Using Infrared Band Data for Evaluating Evapotranspiration of Agricultural Crops (A.A. Feoktistov; journal article abstract; 1 page)

Economic Evaluation of Use of Materials From Space Survey of Earth in Comprehensive Inventory of Natural Resources; D.A. Tashkhodzhayev, et al.; journal article abstract; 1 page)

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| 16. Abstract This is the eleventh issue of NASA's USSR Space Life Sciences Digest. It contains abstracts of 54 papers recently published in Russian language periodicals and bound collections and of four new Soviet monographs. Selected abstracts are illustrated with figures and tables from the original. Additional features include the translation of a paper presented in Russian to the United Nations, a review of a book on space ecology, and report of a conference on evaluating human functional capacities and predicting health. Current Soviet Life Sciences titles available in English are cited. The materials included in this issue have been identified as relevant to 30 areas of aerospace medicine and space biology. These areas are: adaptation, aviation physiology, biological rhythms, biospherics, body fluids, botany, cardiovascular and respiratory systems, cosmonaut training, developmental biology, endocrinology, enzymology, equipment and instrumentation, gastrointestinal systems, group dynamics, genetics, hematology, human performance, immunology, life support systems, mathematical modeling, metabolism, microbiology, musculoskeletal system, neurophysiology, nutrition, operational medicine, perception, personnel selection, psychology, and radiobiology. | | | | | |
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